

# VECTORS AND DISEASE

WHY DOES THE VECTOR MATTER?



**Mosquitoes**



**Ticks**



**Sand flies**



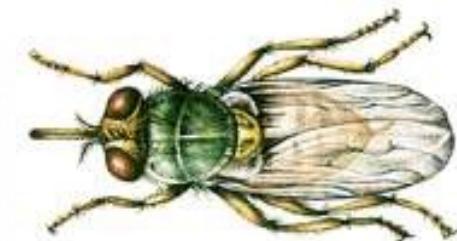
**Fleas**



**Chigger Mites**



**Lice**



**Tsetses**

**COL Jennifer Caci**  
US Army Special Operations Command

Why  
does the  
vector  
matter?



It's not just  
about  
disease...

# OUTLINE

- Threats
  - What does “vector-borne” mean?
  - Understanding vector-borne disease epidemiology
  - Area specific, risk assessment
- Resources
  - Where can you get information?
- Identifying Important Vectors
- Prevention
  - What can you do to minimize risk?

# What is a vector?

- An arthropod that becomes infected with a pathogen and is able to transmit it to another host
- Although an arthropod is able to maintain a parasite alive within its body, transmission depends upon its competence as a vector

# What are the priority threats?

It always depends but, in general according to “the experts”...



REPLY TO  
ATTENTION OF  
MCHE-MDI

DEPARTMENT OF THE ARMY  
BROOKE ARMY MEDICAL CENTER  
3851 ROGER BROOKE DRIVE  
FORT SAM HOUSTON TX 78234-6200

23 April 2010

## MEMORANDUM FOR RECORD

SUBJECT: Infectious Disease Threats to the US Military Prioritization Panel Results

1. A panel was hosted by the Directorate of Combat and Doctrine Development (DCDD) and the Military Infectious Diseases Research Program (MIDRP), US Army Medical Research and Materiel Command (MRMC), under the umbrella of the Medical Force Protection Integrated Capabilities Development Team (ICDT) Charter to prioritize the current infectious disease threats to the US Military (Appendix A).
2. Panel objectives were to identify and operationally prioritize the infectious disease threats to US Forces to assist in the determination of capability requirements.
3. References included "Initial Capabilities Document (ICD) for Infectious Disease Countermeasures (IDCM)," 2006, and "Infectious Diseases Investment Decision Evaluation Algorithm: A Quantitative Algorithm for Prioritization of Naturally Occurring Infectious Disease Threats to the U.S. Military," *Military Medicine* 2008;173:174-181.

## Appendix A

### Prioritization of Infectious Disease Threats to the US Military

1. Malaria
2. Dengue
3. Diarrhea, bacterial
4. Multidrug-resistant (MDR) wound pathogens
5. Leishmaniasis
6. Q fever ( <i>Coxiella burnetii</i> )
7. Norovirus and other viral diarrhea
8. Influenza
9. Adenovirus
10. Leptospirosis
11. Diarrhea, protozoal
12. Tuberculosis (TB)
13. Crimean-Congo hemorrhagic fever
14. Human immunodeficiency virus (HIV/AIDS)
15. Hemorrhagic fever with renal syndrome (HFRS)
16. Chikungunya
17. Meningococcal meningitis
18. Plague
19. Rickettsioses
20. Viral encephalitides
21. Hepatitis E
22. Lassa fever and other arenaviruses
23. Tick-borne encephalitis
24. Rift Valley fever
25. Hepatitis C
26. Brucellosis
27. Other arboviral illnesses
28. Typhoid fever
29. Cholera
30. Schistosomiasis
31. Tularemia
32. Trypanosomiasis
33. Ebola/Marburg hemorrhagic fever
34. Chagas' disease
35. Yellow fever
36. Lyme
37. Bartonellosis (Oroya fever)
38. Soil-transmitted helminths

# PRIORITY THREATS

**1. Malaria**

**2. Dengue**

**4. Leishmaniasis**

**13. CCHF**

**16. Chikungunya**

**18. Plague**

**19. Rickettsioses**

**20. Viral enceph**

**23. TBE**

**24. Rift Valley fever**

**27. Other  
arboviruses**

# Vectorborne Disease Threats

**TABLE I.** Past and present impact of vector-borne diseases of military importance among deployed troops

	Past threats	Present threats	Other diseases of less importance
Sandfly-borne diseases	Sandfly fever Old World cutaneous leishmaniasis New World mucocutaneous leishmaniasis Visceral leishmaniasis	★ Sandfly fever ★ Old World cutaneous leishmaniasis ★ New World mucocutaneous leishmaniasis ★ Visceral leishmaniasis	Oroya fever
Mosquito-borne diseases	Malaria Lymphatic filariasis Yellow fever Japanese B encephalitis Dengue fever Chikungunya disease	★ Malaria ★ Dengue fever ★ Chikungunya disease Rift Valley fever virus ★ West Nile virus	O'nyong nyong virus, Semliki Forest virus, Sindbi virus, and other mosquito-borne viruses
Flea-borne diseases	Plague Murine typhus	Plague? Murine typhus?	Flea-borne spotted fever
Louse-borne diseases	Typhus Trench fever		
Tick-borne diseases	Louse-borne relapsing fever Rocky mountain spotted fever Mediterranean spotted fever African tick bite fever Other common tick-borne spotted fevers Ehrlichiosis Q-fever* Tularemia* Crimean–Congo hemorrhagic fever Tick-borne encephalitis	★ Rocky mountain spotted fever Mediterranean spotted fever African tick bite fever ★ Other common tick-borne spotted fevers Ehrlichiosis ★ Q-fever* Tularemia* ★ Crimean–Congo hemorrhagic fever	New pathogenic rickettsiae ( <i>Rickettsia slovaca</i> , <i>Rickettsia helvetica</i> , and <i>Rickettsia sibirica mongolitimonae</i> ) 'Rickettsia of unknown pathogenicity' Colorado tick fever Kemerovo tick fever Other tick-borne fevers (Dugbe or Banja virus) Omsk hemorrhagic fever Kyasanur Forest disease Alkhurma virus hemorrhagic fever Human babesiosis Babesiosis
Mite-borne diseases	Scrub typhus	Scrub typhus	
Tsetse fly-borne diseases	Sleeping sickness	Sleeping sickness	
Kissing bug-borne diseases	Chagas disease	★ Chagas disease	

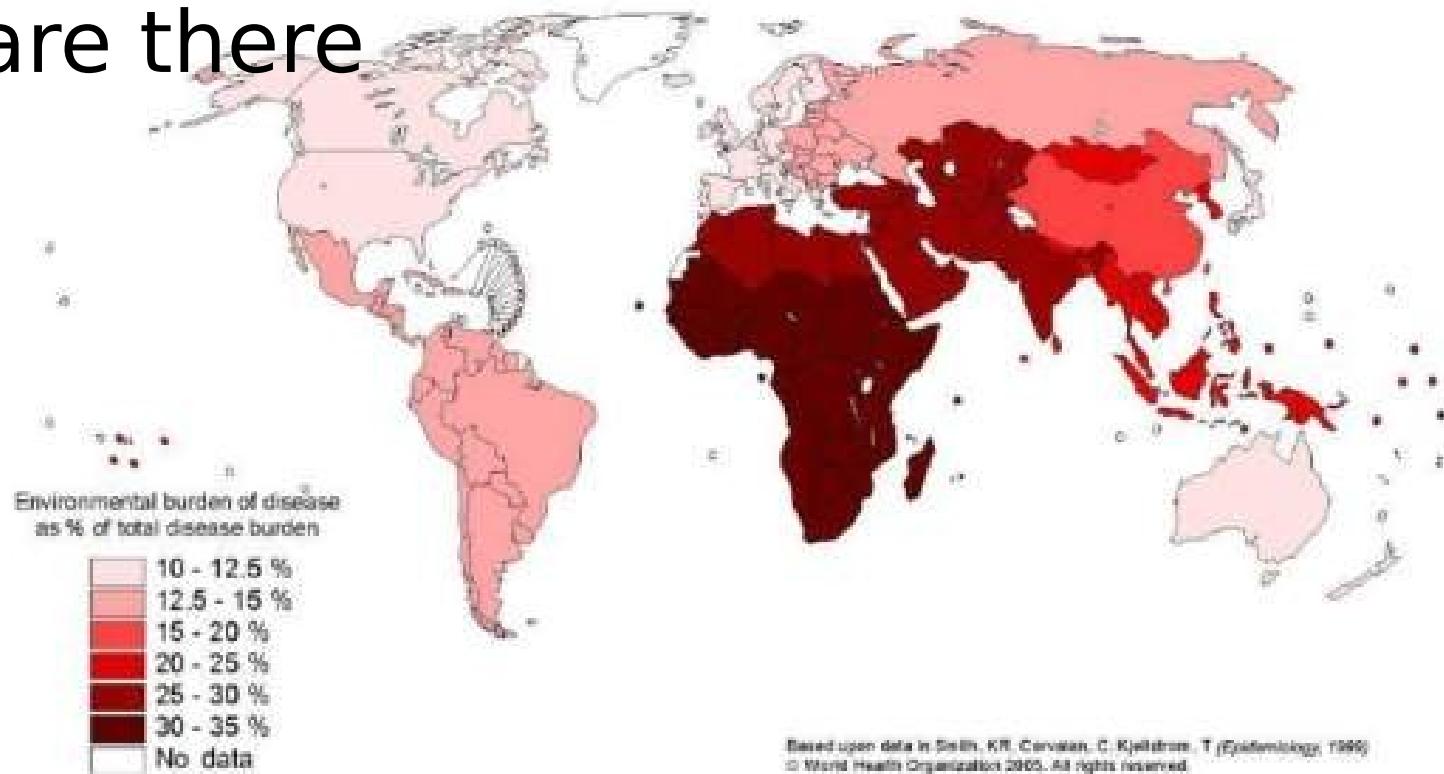
**Pages et al., 2010. The past and present threat of vector-borne diseases in deployed**

\* the main risk for forces is not the vector-borne transmission

# RISK

What are the threats in my AO?

Depends on **where** you are and **when** you are there



# Components of Transmission

## □ Pathogen

- Imported genotypes, mutations, replication rate

## □ Vector

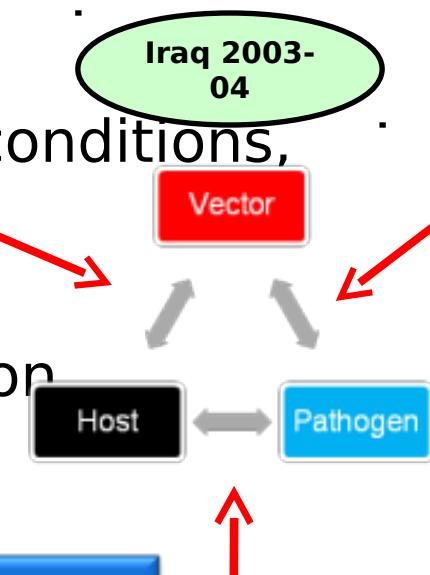
- Feeding behavior, host preference, habitat, vector competence, density, life span

## □ Host and reservoir populations

- Susceptibility, immunity, density, living conditions, movement

## □ Landscape

- Climate, rainfall, temp, humidity, elevation habitat



Where can you break the cycle?

# Factors for Estimating Risk

1. What pathogens and strains/species are present?

*(P. falciparum is far more serious than P. vivax)*

2. Will the mission put personnel into close contact with vectors?

- VECTOR BEHAVIOR
  - *Anopheles* mosquitoes are nighttime biters.
  - *Aedes* mosquitoes are daytime biters.
  - Sandflies typically fly close to the ground.
- VECTOR HABITAT...Will personnel operate in areas with vectors?
- BILLETING...in buildings with doors and screened windows?

3. Will conditions support disease transmission?

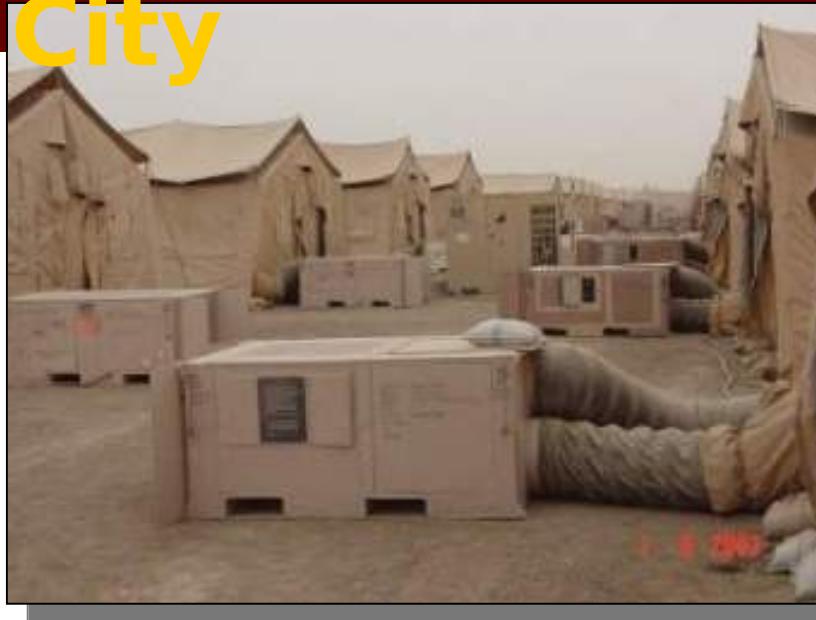
- SEASONALITY
- RECENT WEATHER (rain and mosquitoes, wind and sand flies)
- DENSITY OF VECTOR
- INFECTION RATE

4. What is the Incubation Period?

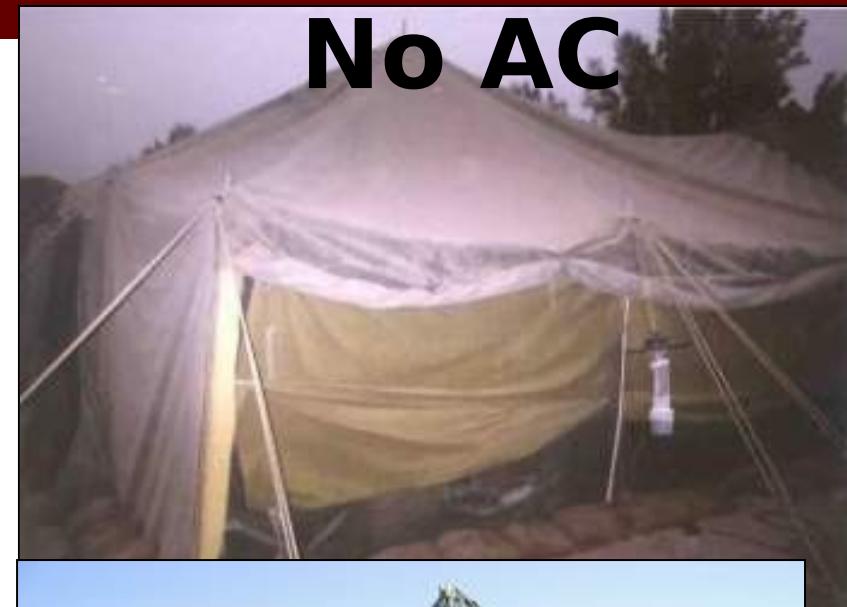
- IMMEDIATE VS. DELAYED IMPACT



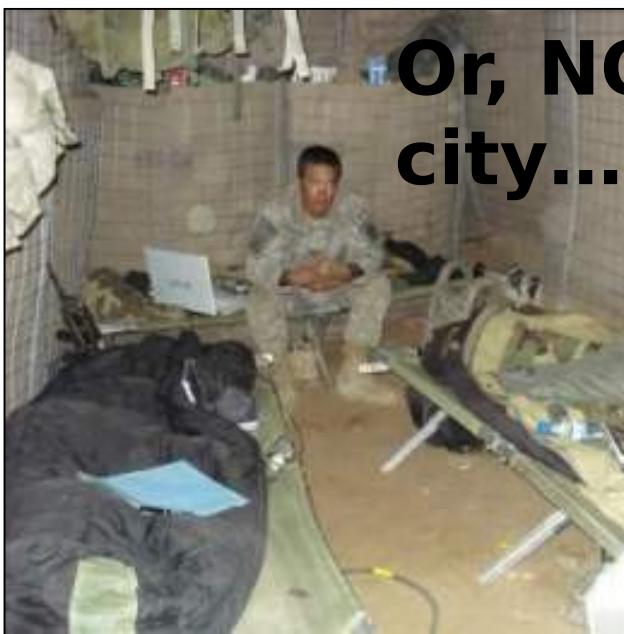
# Air Force Tent City



# Army Tent City



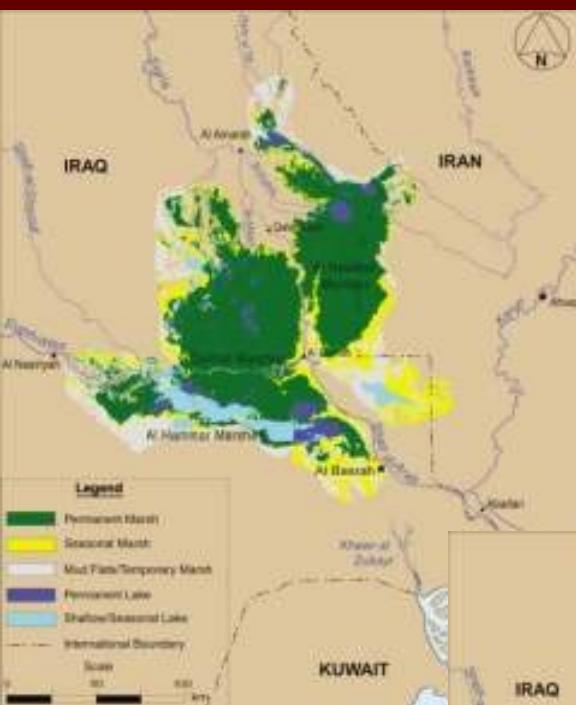
Examples  
of varied  
risk levels  
in austere  
environments



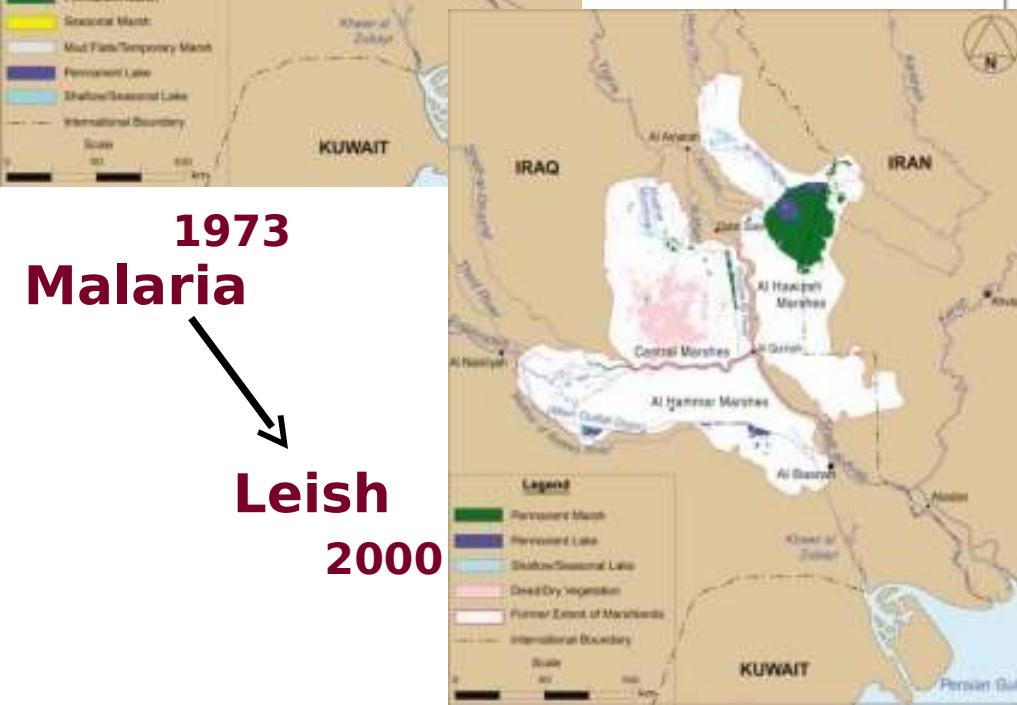
Or, NO tent  
city...



# Ecological Influence- Iraq Example

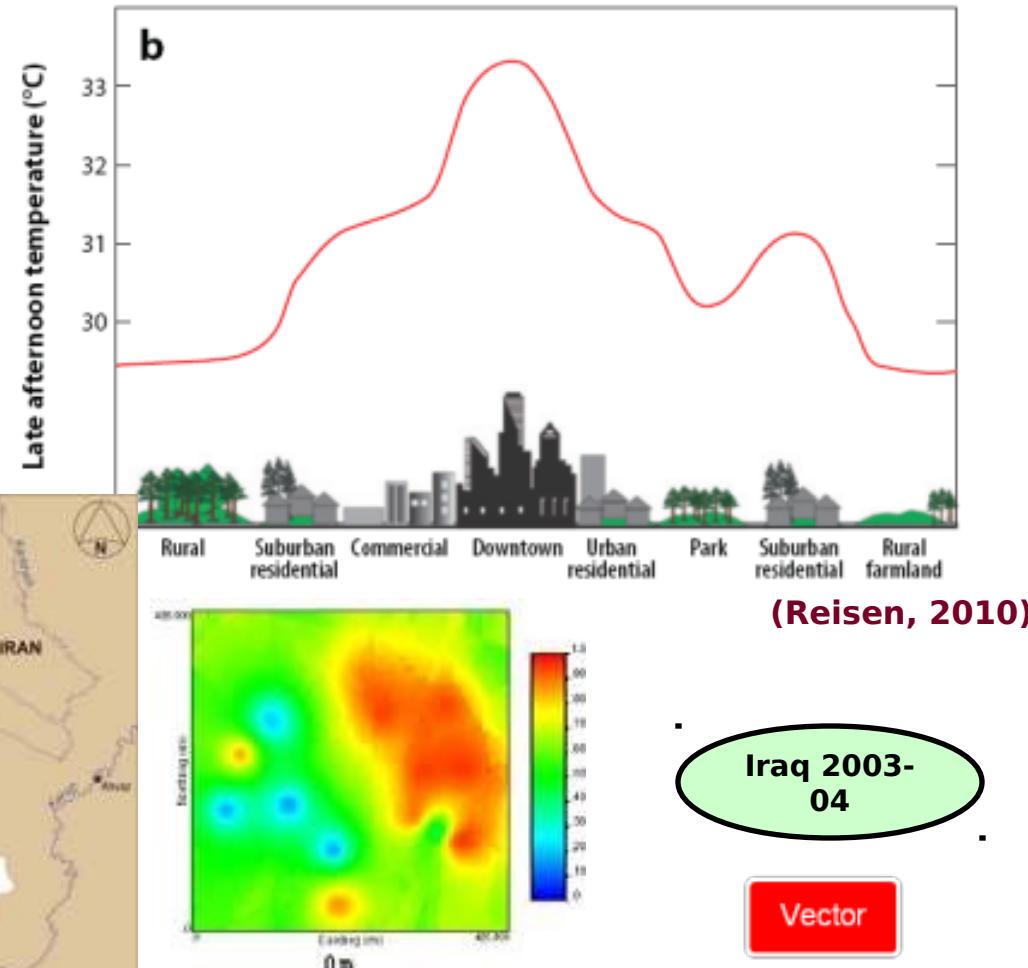


Water (rainfall, I, marshes etc)



1973  
Malaria

Leish  
2000



Land cover and Temperature

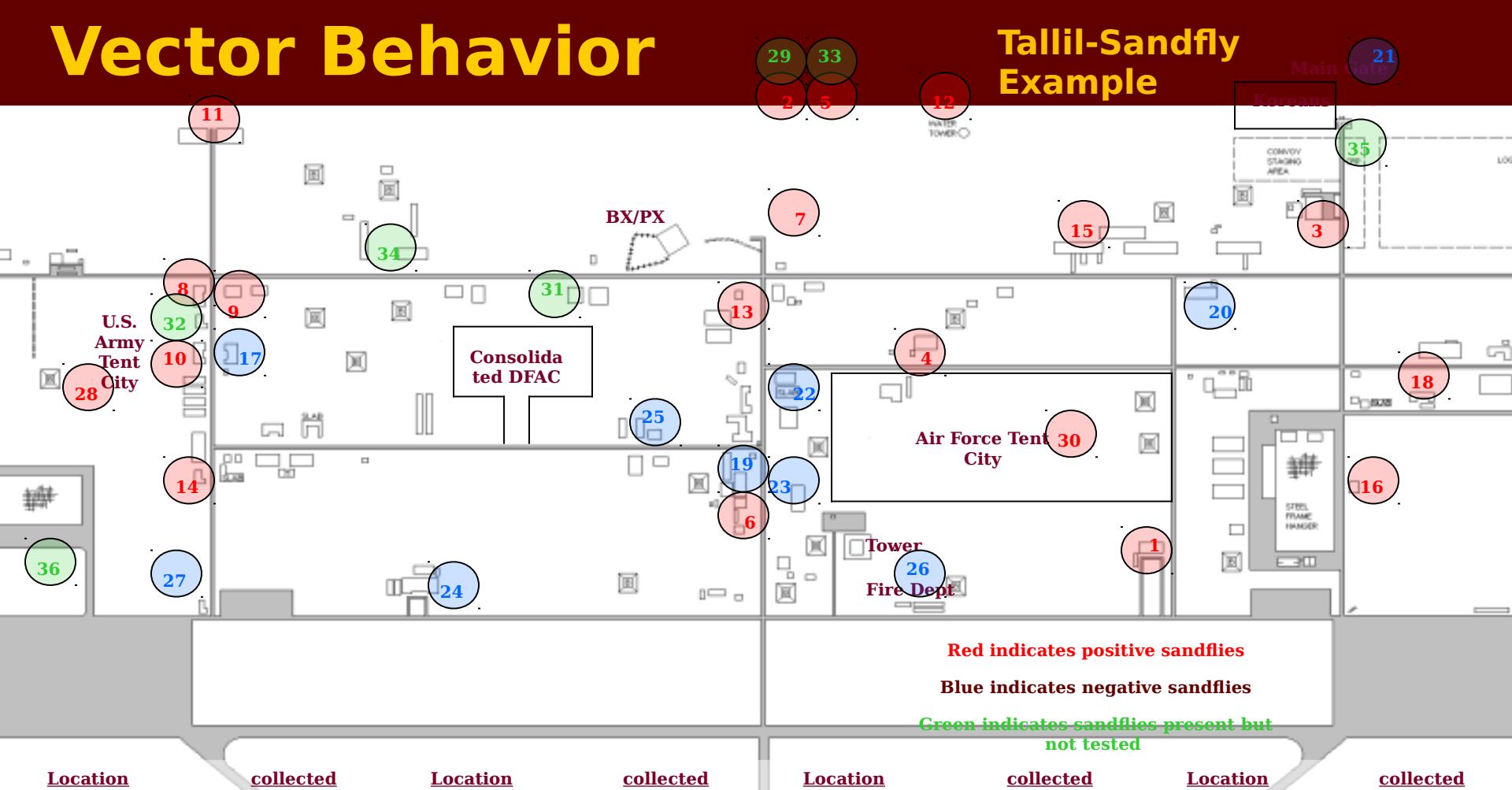
Vector

Host

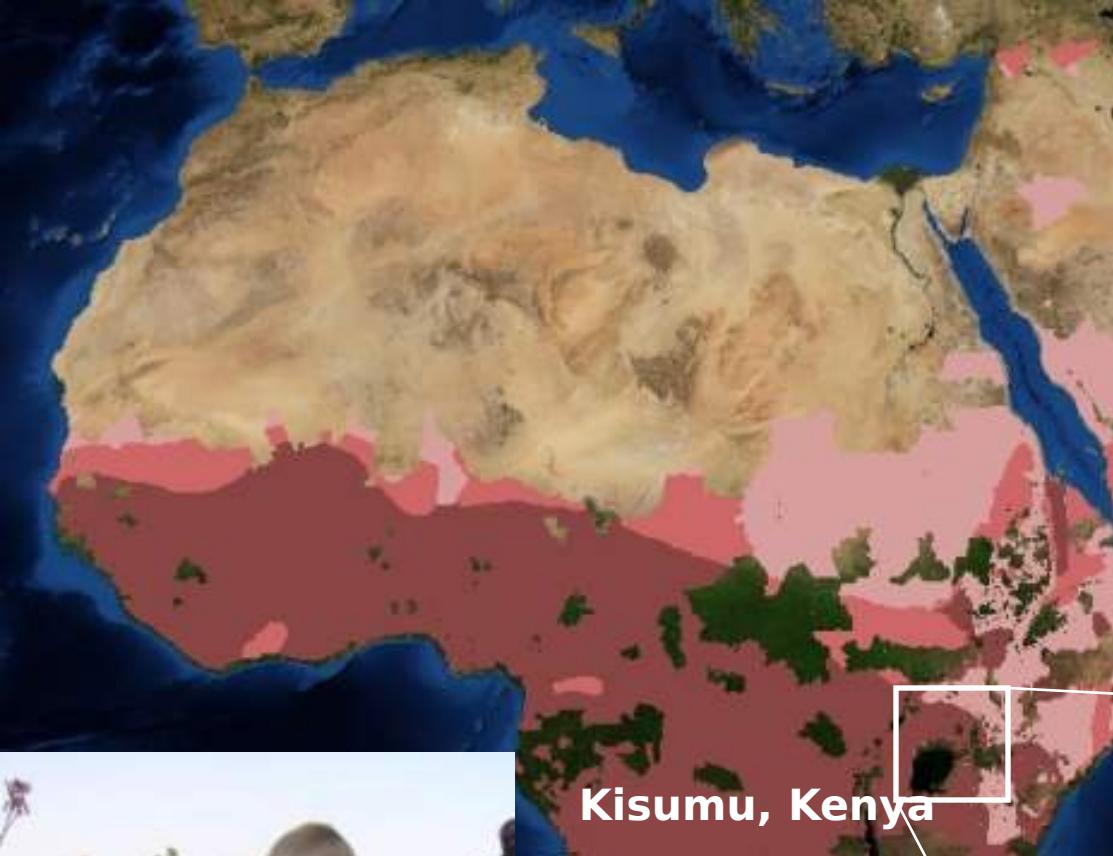
Pathogen

# Vector Behavior

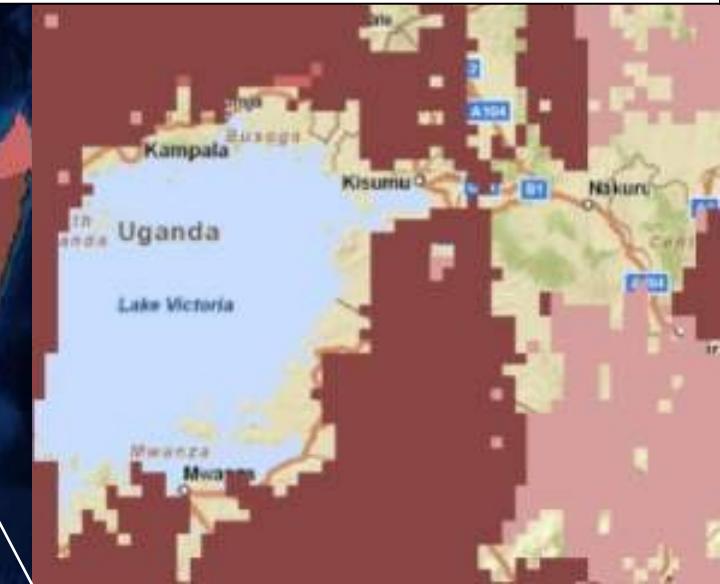
## Tallil-Sandfly Example



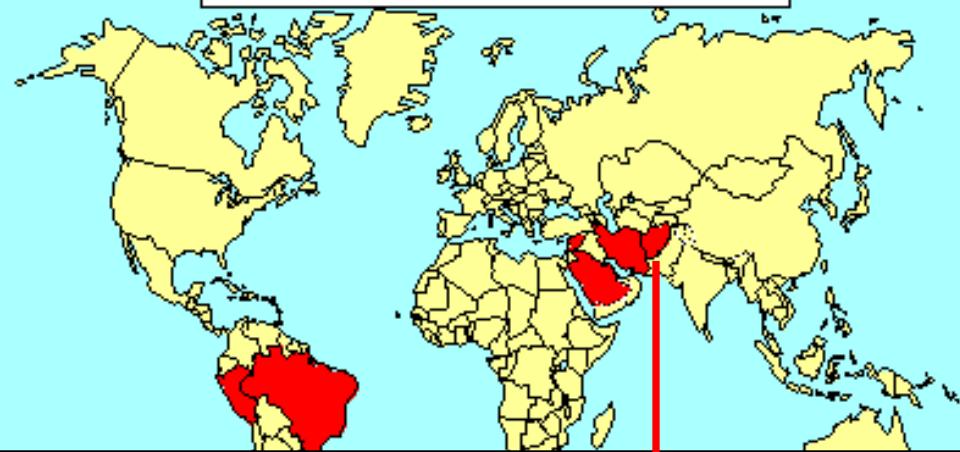
<u>Location</u>	<u>tested</u>	<u>collected</u>	<u>Location</u>	<u>tested</u>	<u>collected</u>	<u>Location</u>	<u>tested</u>	<u>collected</u>	<u>Location</u>	<u>tested</u>	<u>collected</u>
		<u>infected</u>			<u>infected</u>			<u>infected</u>			<u>infected</u>
1. AF-407 <sup>th</sup> AEG TOC	510 2.29%	131	10. Mosque		131 1.12%	89	19. 486 <sup>th</sup> CA Bn	108 0.00%	28. Army Tent City	3,691 1.98%	303
2. Control Site 3	612 0.65%	2,803	11. 2220 <sup>th</sup> Trans	2,064	4,088 1.31%		20. V Corps IG	55 0.00%	29. Control Site 1		1,087
3. 1/293 <sup>rd</sup> INF, HHD	30 4.76%	21	12. 1208 <sup>th</sup> QM Co	3,128	16,280 0.90%		21. Airbase Entrance	53 0.00%	30. AF - Tent City	2,353 2.37%	845
4. AF - Post Office	351 4.05%	74	13. Army Finance	3,217	478 0.21%		22. Laundry/Bath	20 0.00%	31. AF - 407 <sup>th</sup> Maint		612
5. Control Site 4	5,104 803 1.49%		14. 933 <sup>rd</sup> MP Co HQ	749	115 1.74%		23. 63 <sup>rd</sup> Sig Bde	14 0.00%	32. S of 221 <sup>st</sup> MI Bn		454
6. 171 <sup>st</sup> ASG		1,180	15. 744 <sup>th</sup> MP Bn		74 0.00%		24. 86 <sup>th</sup> CSH	10 0.00%	33. Control Site 2		318
									34. AF-Security Force		268
									35. Convoy Center		230



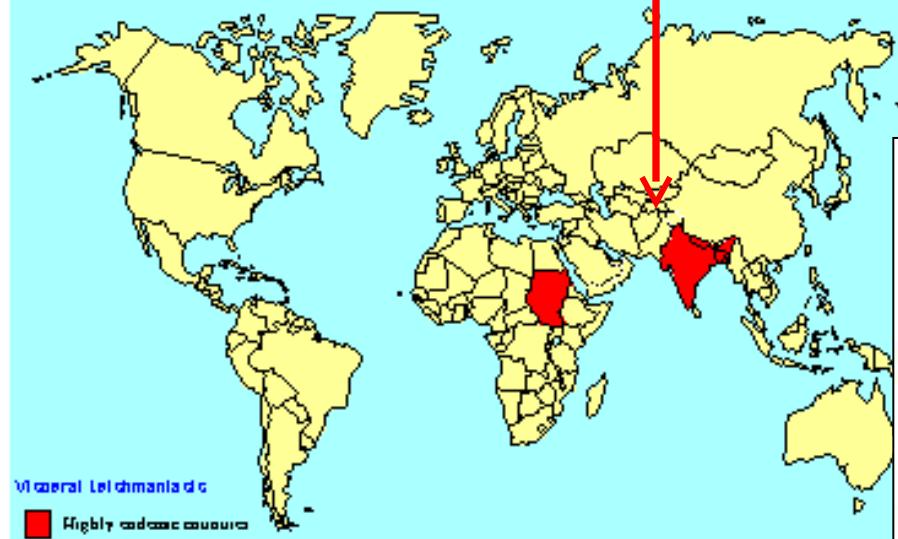
- Model of *P. falciparum*
- No transmission in areas surrounded by high transmission
- Why?
- No vectors; the cycle was broken with appropriate pesticide use



Cutaneous Leishmaniasis  
Highly Endemic Countries (90% of cases)



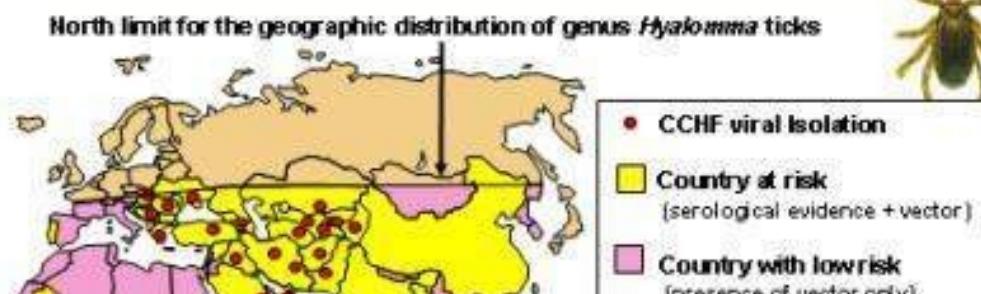
Visceral Leishmaniasis  
Highly Endemic Countries (90% of cases)



Is there effective  
control or is no one  
is looking?



CCHF: geographic distribution



# HELP IN IDENTIFYING PRIORITY THREATS

- **Entomological Operational Risk Assessments (EORA)**
  - Provide risk estimates for vector-borne and zoonotic diseases in the country of concern.
  - These estimates, prepared by USAPHC.
  - EORAs available for >30 countries.
- **Infectious Disease Risk Assessment (IDRA)**
  - AFMIC now NCMI
  - Web-based and CD (MEDIC)
  - Classified and unclassified medical intelligence/information
- **Disease Vector Ecology Profiles (DVEP)**

<http://www.afpmb.org/cont/ent/disease-vector-ecology-profiles>
- **Geosentinel**
- **ProMed**

# RESOURCES

## Where can you find answers?

- Regional Public Health Command (PHC), Ento Div  
<http://chppm-www.apgea.army.mil/ento/default.htm>
- AFPMB  
<http://www.afpmb.org>
- NCMI (MEDIC CD)
- WRAIR Ento Div
- Walter Reed Biosystematics Unit (WRBU)  
<http://wrbu.si.edu> and  
<http://mosquitomap.nhm.ku.edu/vectormap/>
- Command PM assets



# Armed Forces Pest Management Board

recommends policy, provides guidance, and coordinates the exchange of information on all matters related to DoD pest management

[Log in](#) [Register](#)

## Search AFPMB.org

- [Search the AFPMB Website](#)

## Questions?

- [Send a question to the Board](#)

## DoD Topics

- [Pesticide & Equipment Lists](#)
- [Training & Certification](#)
- [DoD Pesticide Hotline](#)

## Literature



## Hosted Sites



## Military Entomology



## Board Meeting Info

 [Next Board Meeting:](#)  
Oct. 31 - Nov 4, 2011

- [Information from last meeting](#)
- [Board Minutes & Staff Reports](#)
- [Committee Workspaces](#)



## Contingency & Deployment Resources

We provide support to DoD personnel on any pest management issue in any situation. We also provide rapid accurate responses to questions regarding all aspects of pest management and maintain the website to meet the needs of our customers. [Find a resource now!](#)

## Literature Retrieval System

Our Literature Retrieval System is an online collection of scientific papers comprising over 100,000 documents in searchable PDF format, drawn from our extensive library of books, journals, reprints, reports, and other sources. [Search our database of over 120,000 PDFs](#)

## Deployed War-Fighter Protection (DWFP) Program

The Deployed War-Fighter Protection research program (DWFP) is an initiative to develop and validate novel methods to protect United States Military deployed abroad from threats posed by disease-carrying insects. [Read more](#)

## Disease Vector Ecology Profiles

Disease Vector Ecology Profiles (DVEPs) summarize unclassified literature on medically important arthropods, vertebrates and plants that may adversely affect troops in specific countries or regions of the world. [Read more](#)

## Technical Guides

As a unit of the AFPMB, ISD (Information Services Division) collects, stores and disseminates published and unpublished information on arthropod vectors and pests, natural resources, and environmental biology important to the DoD. [Read more](#)

## Living Hazards Database

The Living Hazards Database (LHD) is a comprehensive compilation of more than 500 species worldwide, which are reported to cause serious injury or death of humans. [Read more](#)

## What's New

- [Audrey Perich and Brian Zeichner receive award for development of lethal trap](#)
- [Report of the 5th Annual Meeting of the Roll Back Malaria Partnership](#)
- [Roll Back Malaria Progress & Impact Series](#)
- [Archives](#)

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# REGIONAL RISK

## DVEPS

- Provide risk estimates for vector-borne and zoonotic diseases in the regions of concern.
- Prepared by AFPMB.



Office of the Deputy Under Secretary of Defense for Installations & Environment

## Regional Disease Vector Ecology Profile

### South Central Asia



Defense Pest Management Information Analysis Center  
Armed Forces Pest Management Board  
Forest Glen Section  
Walter Reed Army Medical Center  
Washington, DC 20307-5001

Homepage: <http://www.afpmb.org>

September 2001

The Walter Reed Biosystematics Unit (WRBU) is a unique national resource. Its mission is to conduct systematics research on medically important arthropods and to maintain the U.S. mosquito collection. The WRBU is just one part of the U.S. Government's entomological research system, which includes the U.S. Department of Agriculture (USDA) and the Smithsonian Institution (SI). Historically, mosquito identification was managed by USDA and the SI, but in 1972 this responsibility was transferred from USDA to the U.S. Army for research on medically important arthropods. Located at the Museum Support Center of the Smithsonian Institution in Suitland, Maryland, the WRBU's physical space is provided by the Smithsonian Institution in return for curation of the collection and specimen identification... [\(more\)](#)

## What's New?

Mosquito Classification 2010 

Discussion Forum

New mosquito identification keys

See new WRBU staff publications

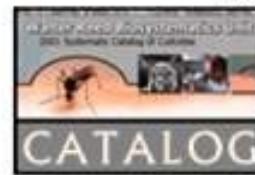


MosquitoMap.org  
SandflyMap.org  
TickMap.org



## Vector Identification Resources

to medically important arthropods and WRBU's Vector Identification Service



Culicidae Catalog  
[www.mosquitocatalog.org](http://www.mosquitocatalog.org)



Mosquito Genera



Mosquito Literature

### Mosquito Resources



Medically important Mosquitoes

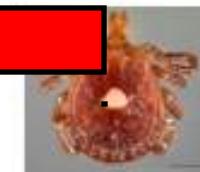


Mosquito Species  
Identification Keys

### Other Vectors



Sand Flies



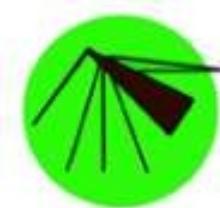
Ticks



Scorpions



Fleas



# VectorMap



- Comprised of MosquitoMap, SandflyMap and TickMap
- Geospatially referenced clearinghouses for arthropod disease vector species collection records and distribution models.
- Users can pan and zoom to anywhere in the world to view the locations of:
  - past **vector collections** and
  - the **results of modeling that predicts the geographic extent of individual species.**

<http://mosquitomap.nhm.ku.edu/vectormap/>

VectorMap is new and still in the test phase.

Requires you to download Silver Light freeware from Microsoft.

# Model of *Plasmodium falciparum* in 2005 from the Malaria Atlas Project

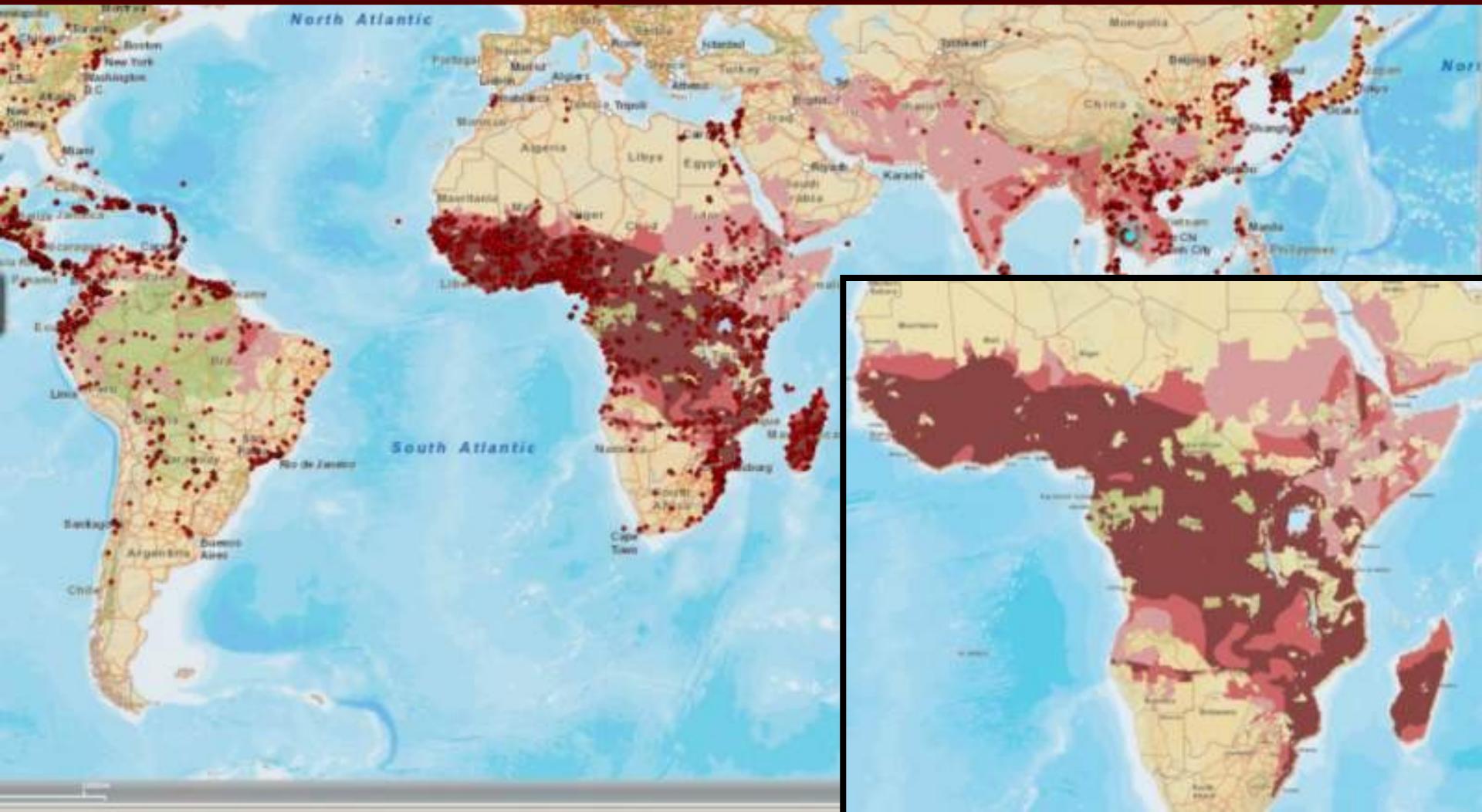
<http://www.map.ox.ac.uk/index.htm>.

Hypoendemic, Mesoendemic and Hyper-holoendemic

Several sources of information on malaria risk (notably international travel health guidelines on malaria chemoprophylaxis, altitude limits for dominant vectors, climate limits for malaria transmission and human population density thresholds) have been combined in a GIS to generate this map. See Guerra et al. (2006) Advances in Parasitology 62: 157 - 179 and Guerra et al. (2006) Trends in Parasitology 22: 353 - 358 for details.

The method for defining the endemic levels within these limits can be found in Snow et al. (2005) Nature 434: 214 - 217.

Anopheles collection records show up as red dots



# Tick collection records



# Emerging and Neglected Vectorborne Disease Threats

- Malaria
- Dengue
- Chikungunya
- Zika
- Filariasis
- Leishmaniasis
- Rickettsioses
  - (e.g. CCHF, African tick bite fever)
- African Trypanosomiasis
- Onchocerciasis



**Mosquito**

**Tsetse Fly**

**Sand Fly**

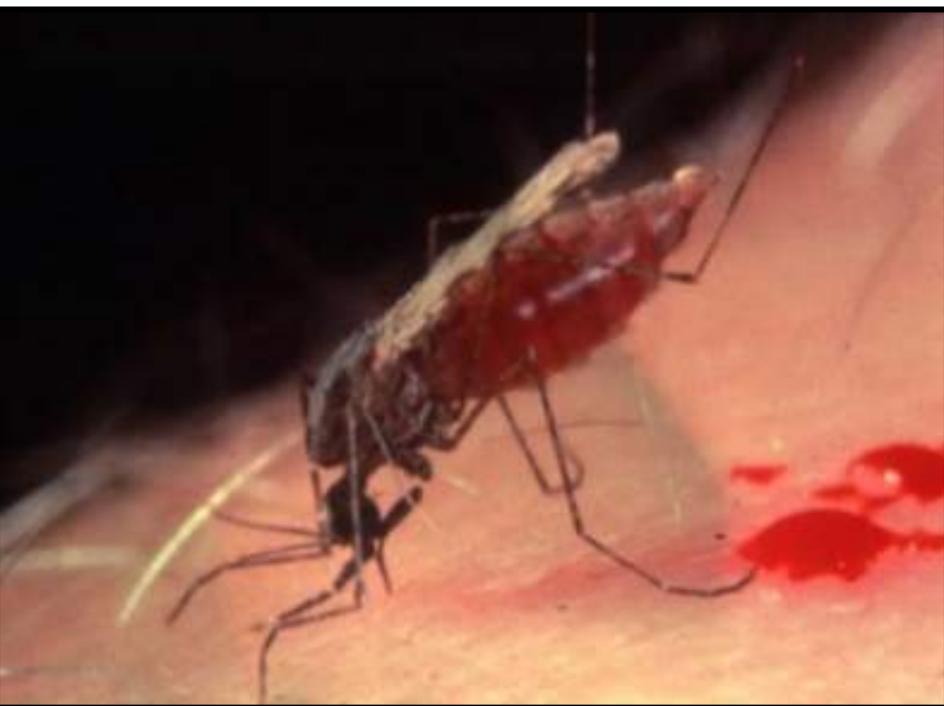
**Tick**

**Black Fly**

# What is a vector?

- An arthropod that becomes infected with a pathogen and is able to transmit it to another host.
- Although an arthropod is able to maintain a parasite alive within its body, transmission depends upon its competence as a vector.
- Requires a blood meal to reproduce; spreads disease incidentally.

# Blood required for egg development



# Vector Potential

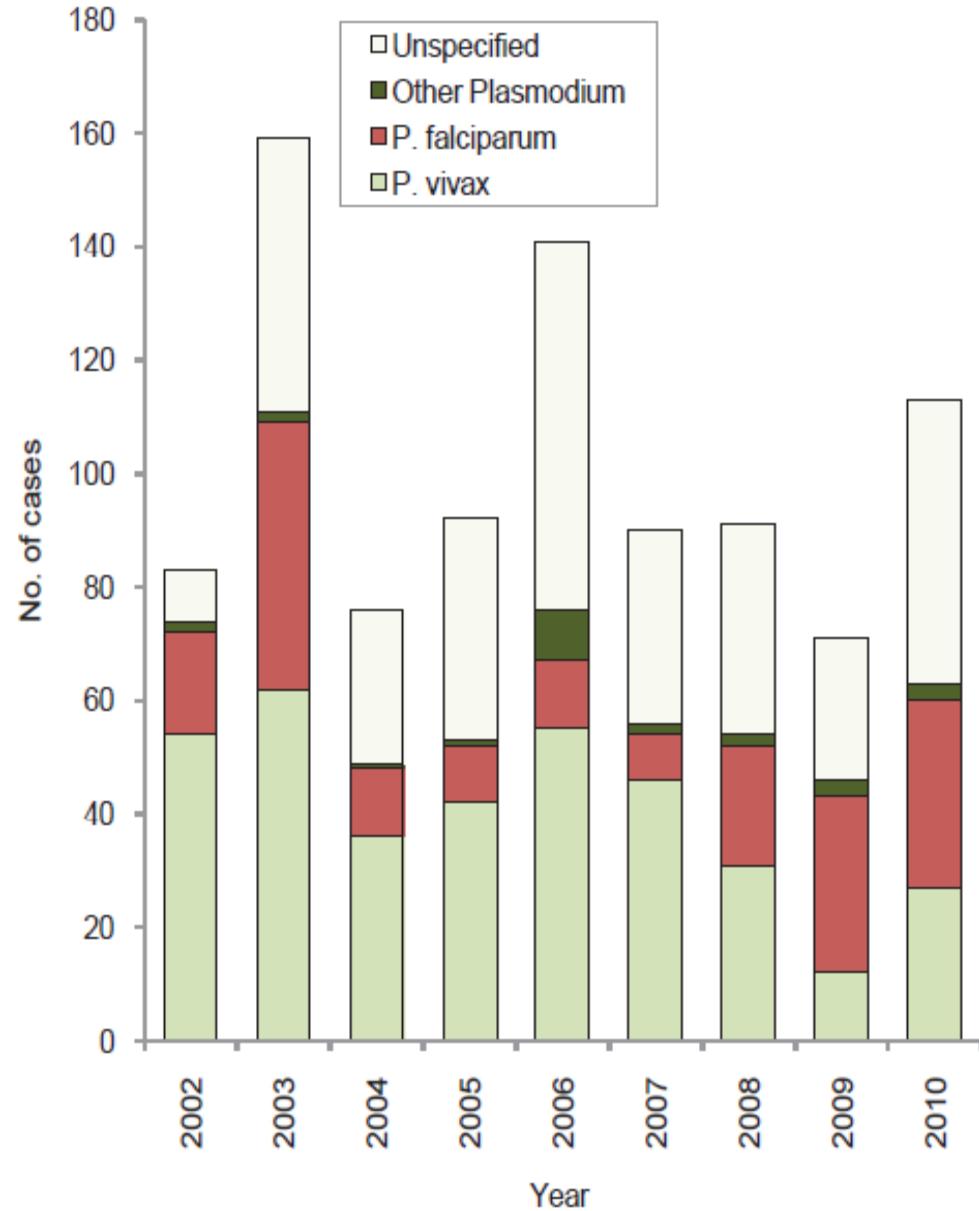
- Mosquito species vary in their vector potential because of environmental conditions and factors affecting their **abundance, blood-feeding behavior, survival, and ability to support parasite development (this all influences competence)**
- Sporogony is the complex life cycle of the malaria parasite in female mosquitoes; completed life cycle is necessary for disease transmission.
- Most individual mosquitoes that ingest gametocytes from the reservoir or host do not support development to the sporozoite stage.

# Malaria- Anopheles mosquitoes



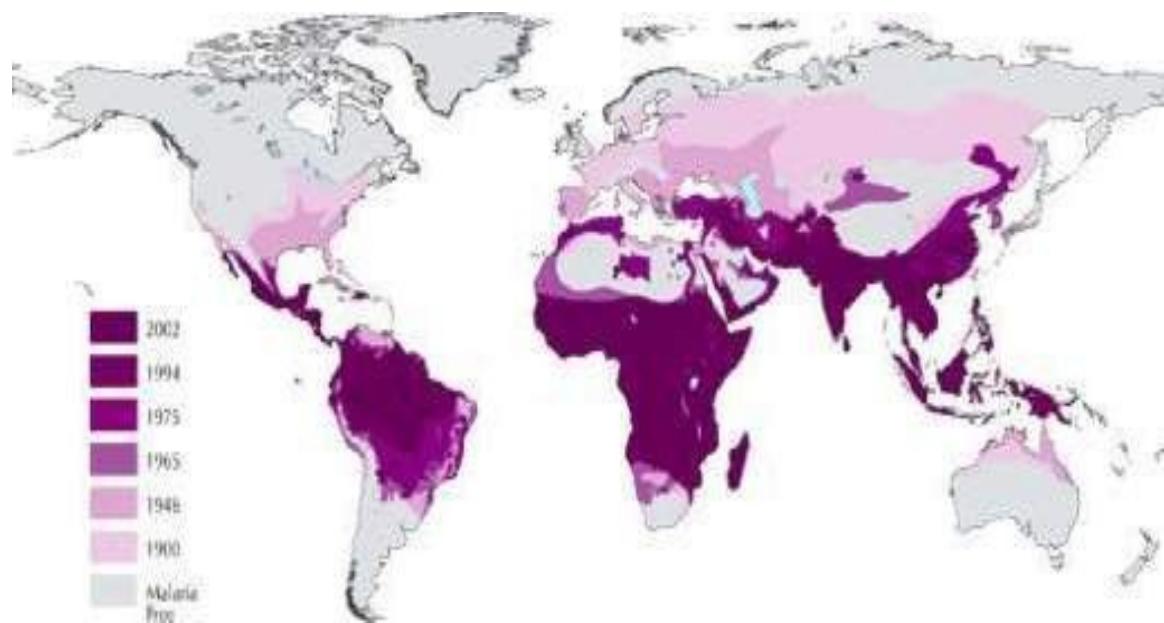
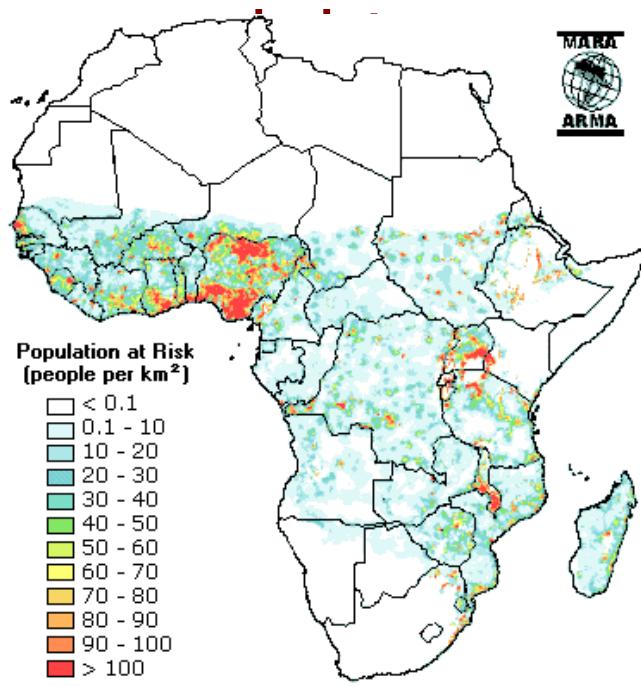
**~100 cases per year  
in US forces in AFG;  
likely under  
reported**

**Figure 1.** Malaria cases among U.S. service members, by *Plasmodium* species and calendar year of diagnosis/report, 2002-2010



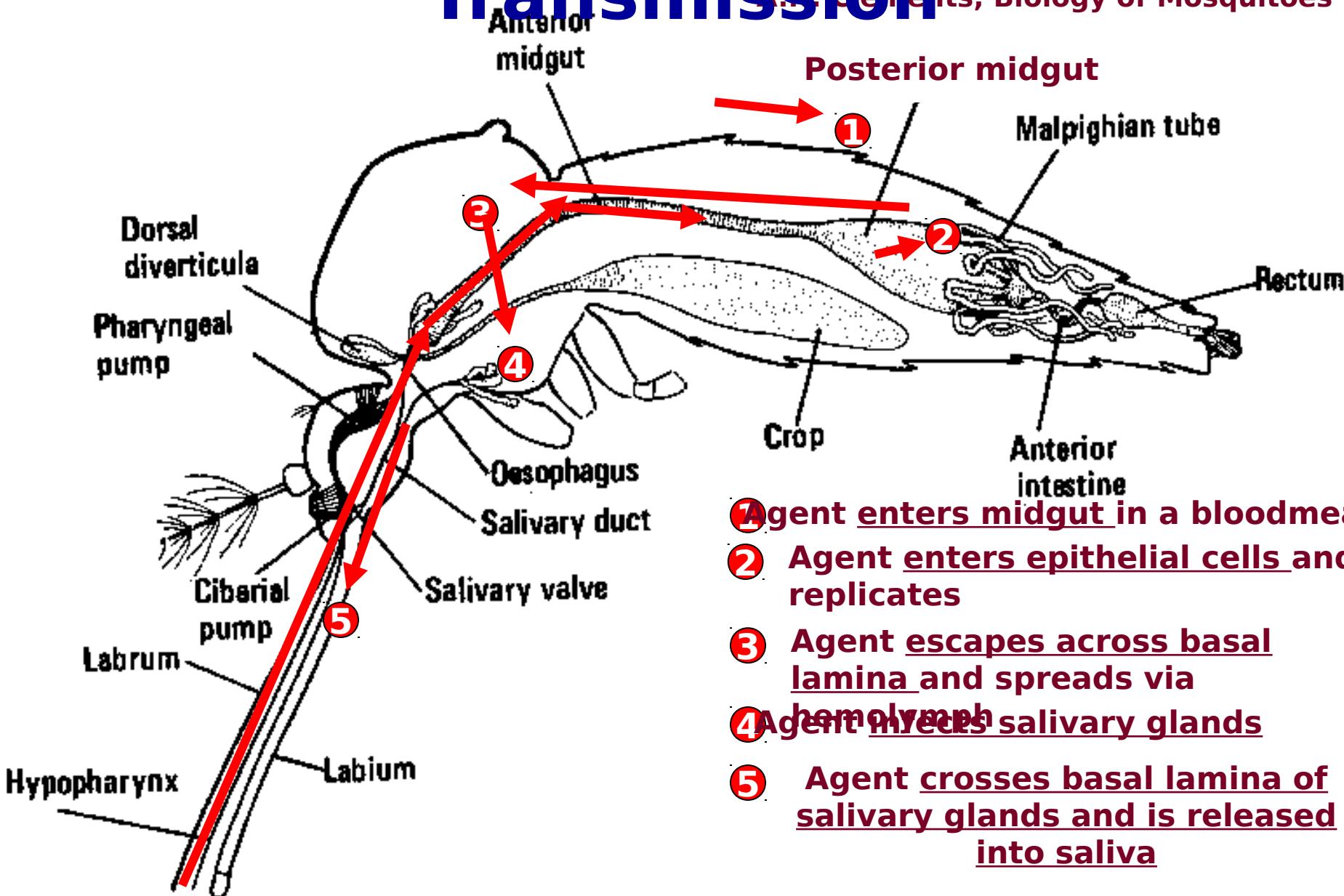
# Malaria- Anopheles mosquitoes

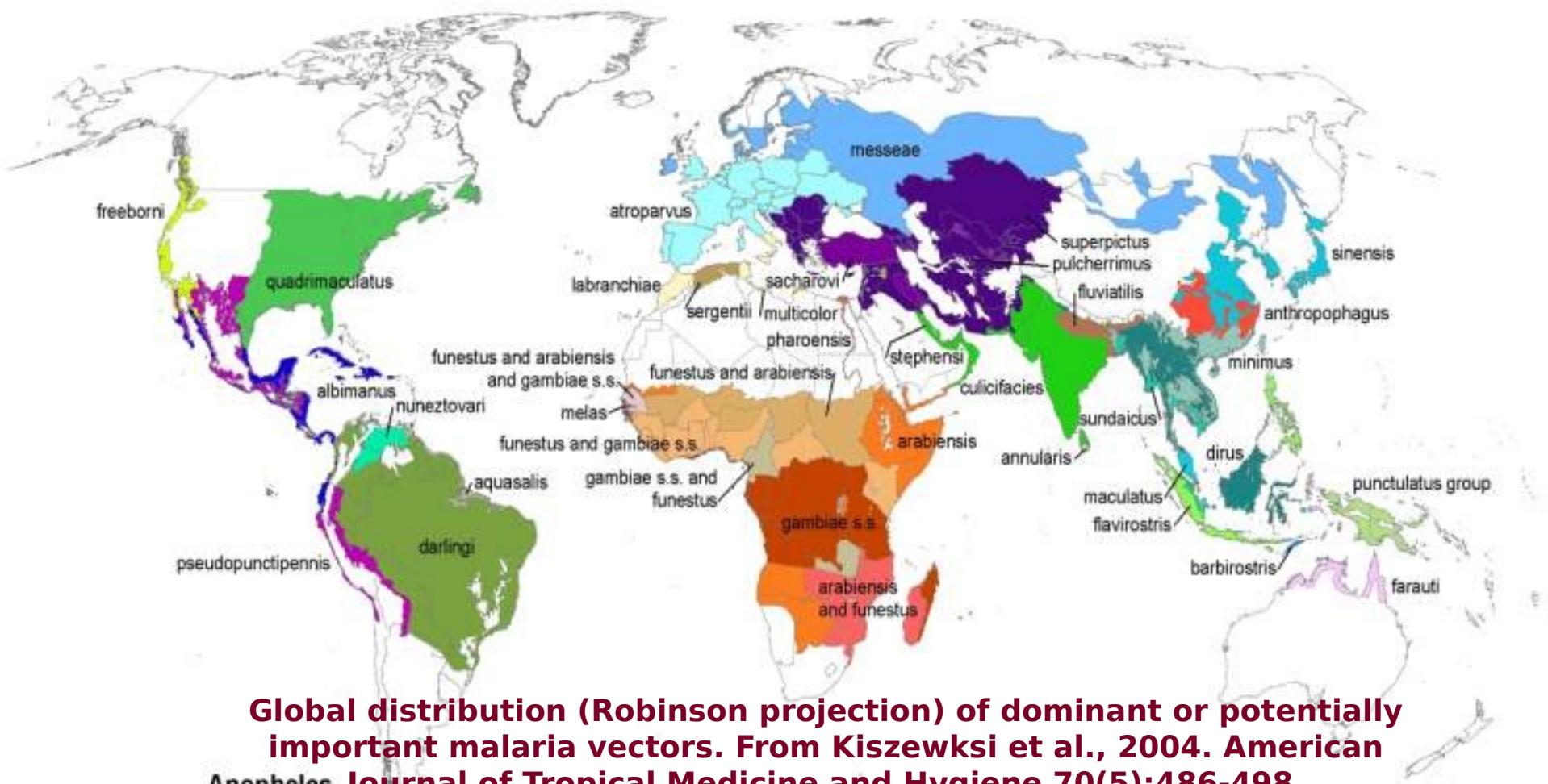
- Risk varies geographically
  - Different species of **Anopheles** mosquitoes (varying competence)
  - Entomological inoculation rate (EIR).
    - An estimate of exposure to infective mosquitoes,
    - EIRs can exceed 1 infective bite per person per



# Barriers to Pathogen Transmission

A. M. Clements, Biology of Mosquitoes





**Global distribution (Robinson projection) of dominant or potentially important malaria vectors. From Kiszewksi et al., 2004. American Anopheles Journal of Tropical Medicine and Hygiene 70(5):486-498.**

No vector	barbirostris	funestus and arabiensis	melas	pulcherrimus
albimanus	culicifacies	funestus, arabiensis and gambiae s.s.	messeae	quadrimaculatus
annularis	darlingi	funestus and gambiae s.s.	minimus	sacharovi
anthropophagus	dirus	gambiae s.s.	multicolor	sergentii
arabiensis	farauti	gambiae s.s. and funestus	nunez-tovari	sinensis
arabiensis and funestus	flavirostris	labranchiae	punctulatus group	stepensi
aquasalis	flaviatilis	maculatus	pharoahensis	sundaicus
atroparvus	freeborni	marajoara	pseudopunctipennis	superpictus

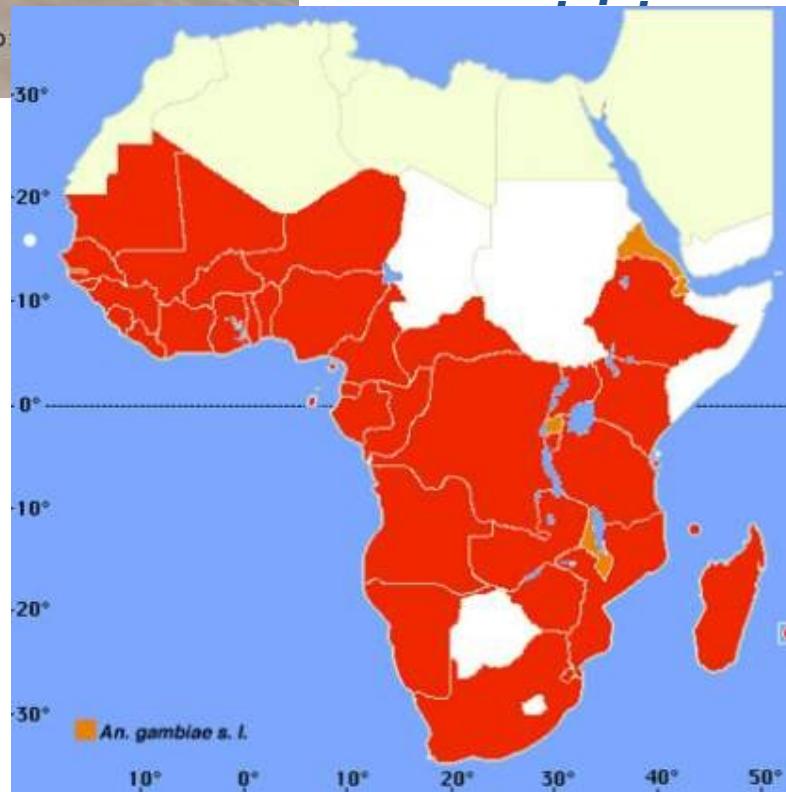
# *Anopheles gambiae* complex

*Anopheles arabiensis*  
*Anopheles bwambae*  
*Anopheles merus*  
*Anopheles melas*  
*Anopheles quadriannulatus*  
*Anopheles gambiae* sensu  
lato



Anopheles gambiae / photo:

***An. gambiae* s. str.:**  
very  
anthropophilic,  
night biter;  
Africa's primary  
malaria vector



# Biology of *Anopheles spp.*

## Eggs

- Eggs are laid individually on the water surface and are kept afloat by air chambers (floats)
- Females lay batches of 75 to 150 eggs
- The eggs hatch after two or three days at temperatures of 25-30°C
- At lower temperatures, this period can be longer, and the eggs can resist total or partial desiccation in moist soil for many days (up to years)
- Oviposition (egg laying) sites vary by species



University of Florida

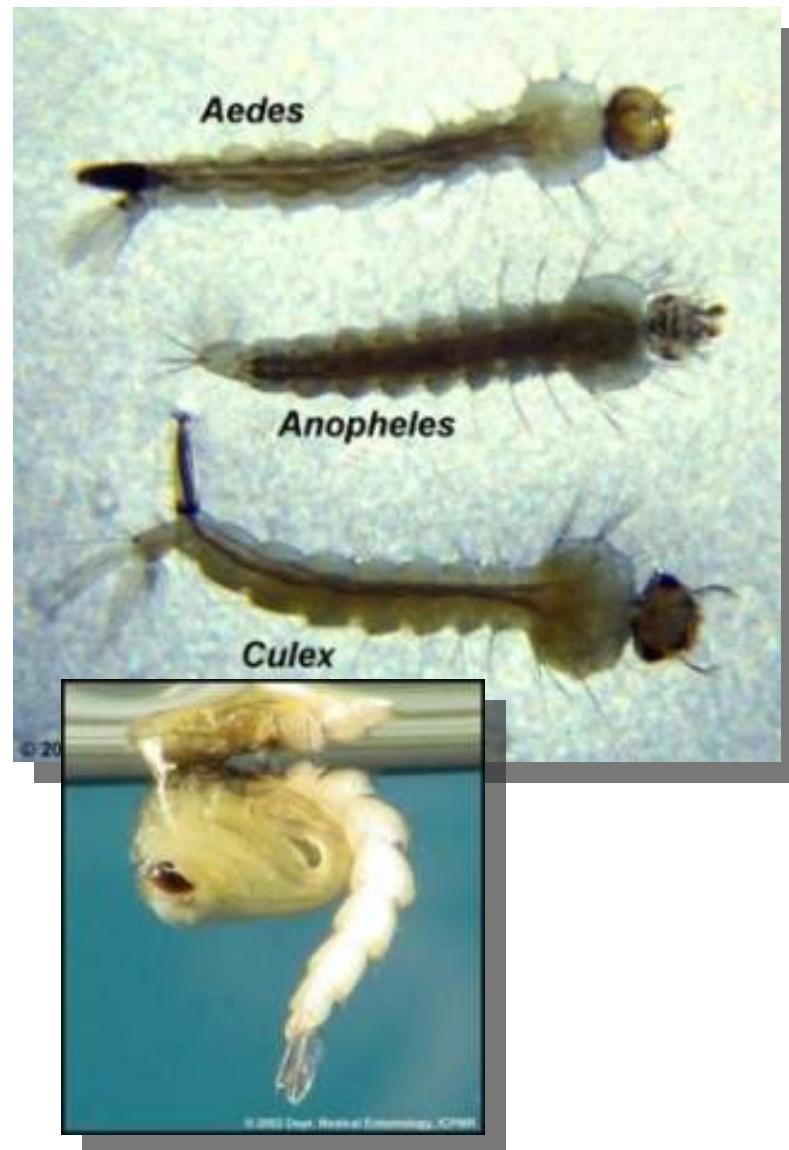
# Biology of *Anopheles* spp.

## Larvae

- Characteristic resting position, lying parallel to the water surface
- Larval development takes around 5 to 7 days depending on temperature
- Larval habitat varies with species

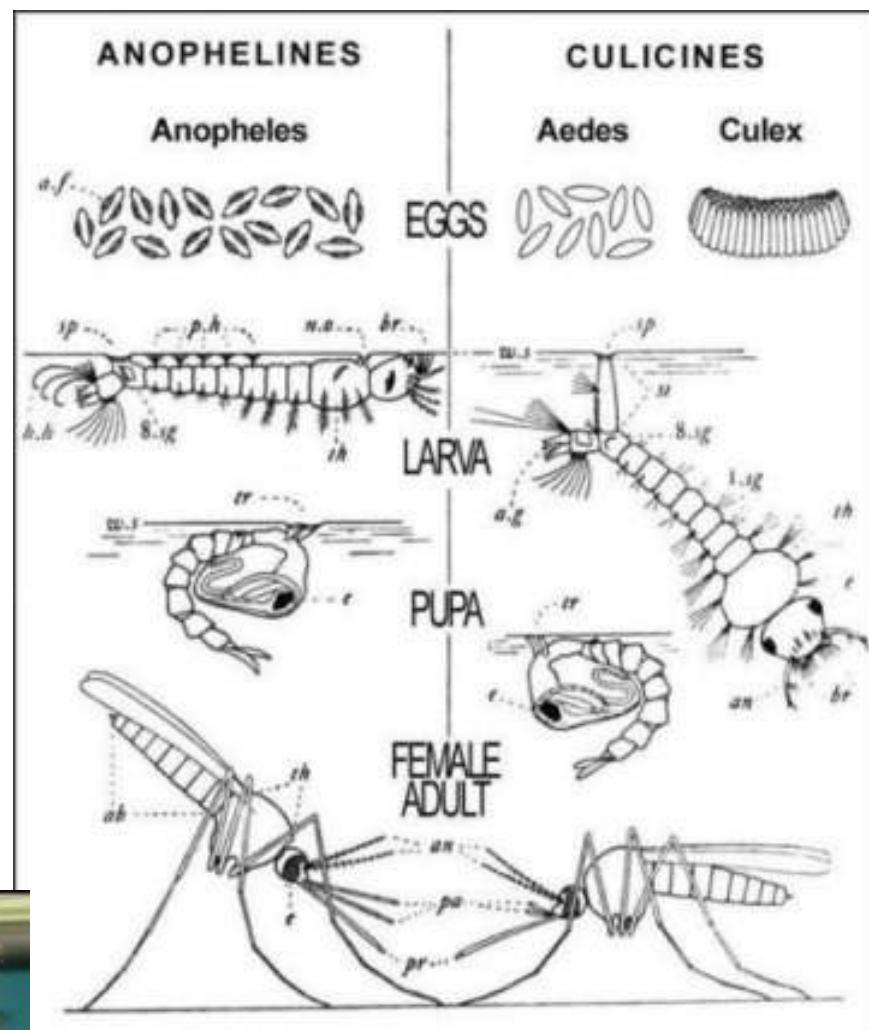
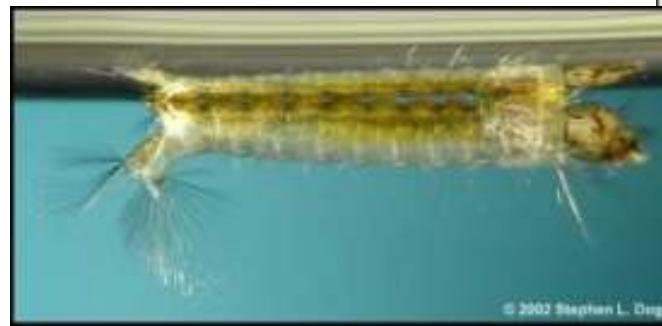
## Pupae

- Pupae do not eat
- Metamorphosis of the larva into an adult
- It lasts from two to three days



# Biology of *Anopheles spp.*

- Larvae lack a siphon
- Larvae rest parallel to water surface
- Breathe through spiracle on 8<sup>th</sup> body segment
- Adults hold body at an angle of 30° degrees or more with the surface.



# Biology of *Anopheles spp.*

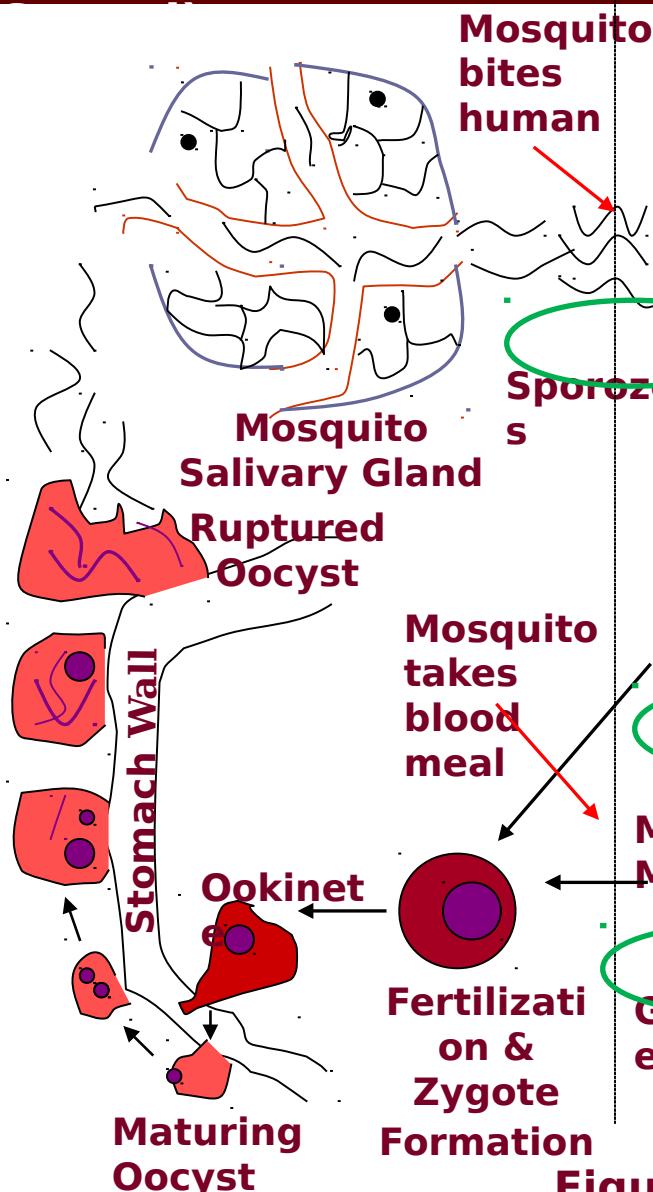
## Adult:

- Live from 3 to 4 weeks although some can overwinter.
- Feeding occurs at night (dusk to dawn).
- Host preference varies by species.
- **Indoor vs. outdoor feeding.**
- **Complicated sexual stage of parasite life cycle occurs in mosquito**



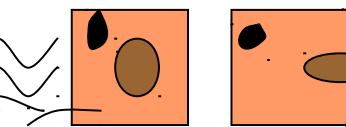
# *P. falciparum* Transmission Cycle

## Cycle in Mosquito



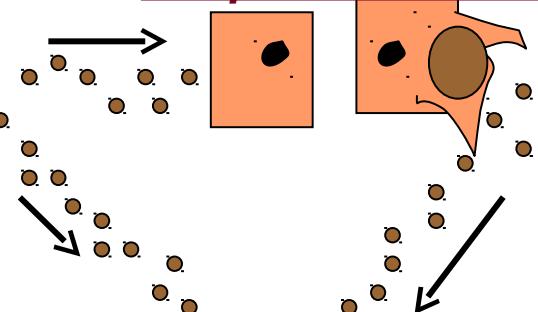
## Cycle in Man

### Primary Tissue Schizont

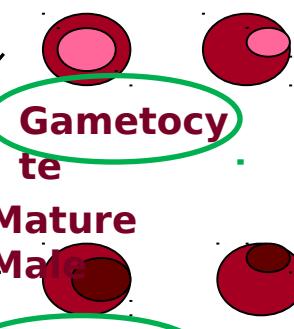


Liver Cells

### Secondary Tissue (does not occur in *P. falciparum* malaria)



### Mature Female



### Gametocyte

### Mature Male



### Fertilization & Zygote Formation

### Gametocyte

### Red Blood Cell

### Early Trophozoite



### Ruptured Cell

### Mature Schizont

### Immature Schizont

### Late Trophozoite

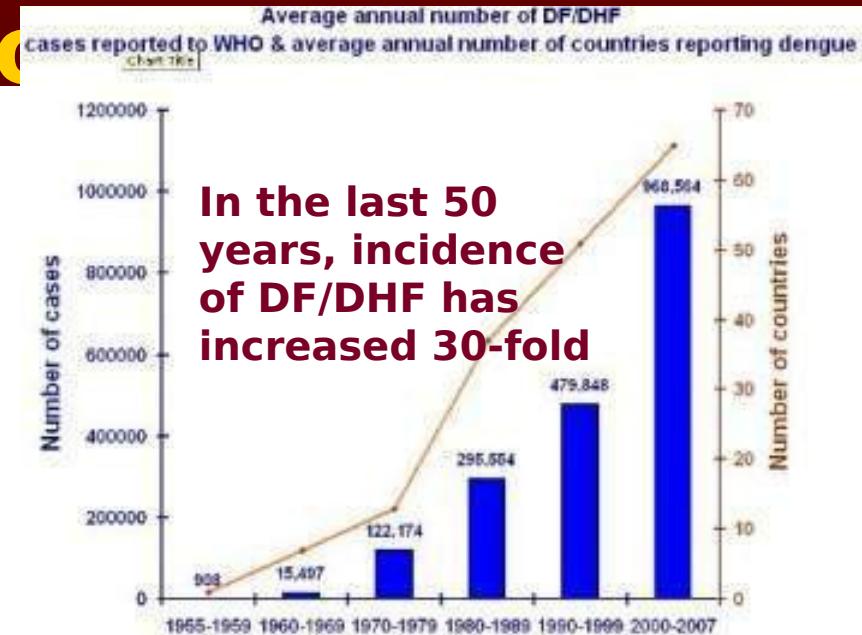
Figure 1 The malaria cycle.

# Life cycle - Sexual stage



# Dengue- Aedes quito

## Laboratory-Confirmed DHF in the Americas Prior to 1981 vs. 1981 - 2003



## Emergence of DEN/DHF



- Endemicity has increased from 9 countries to over 100 countries since the 1970s
- The dengue transmission cycle occurs in the US
- No vaccine; treatment basically limited to supportive care

As of fall 2013:

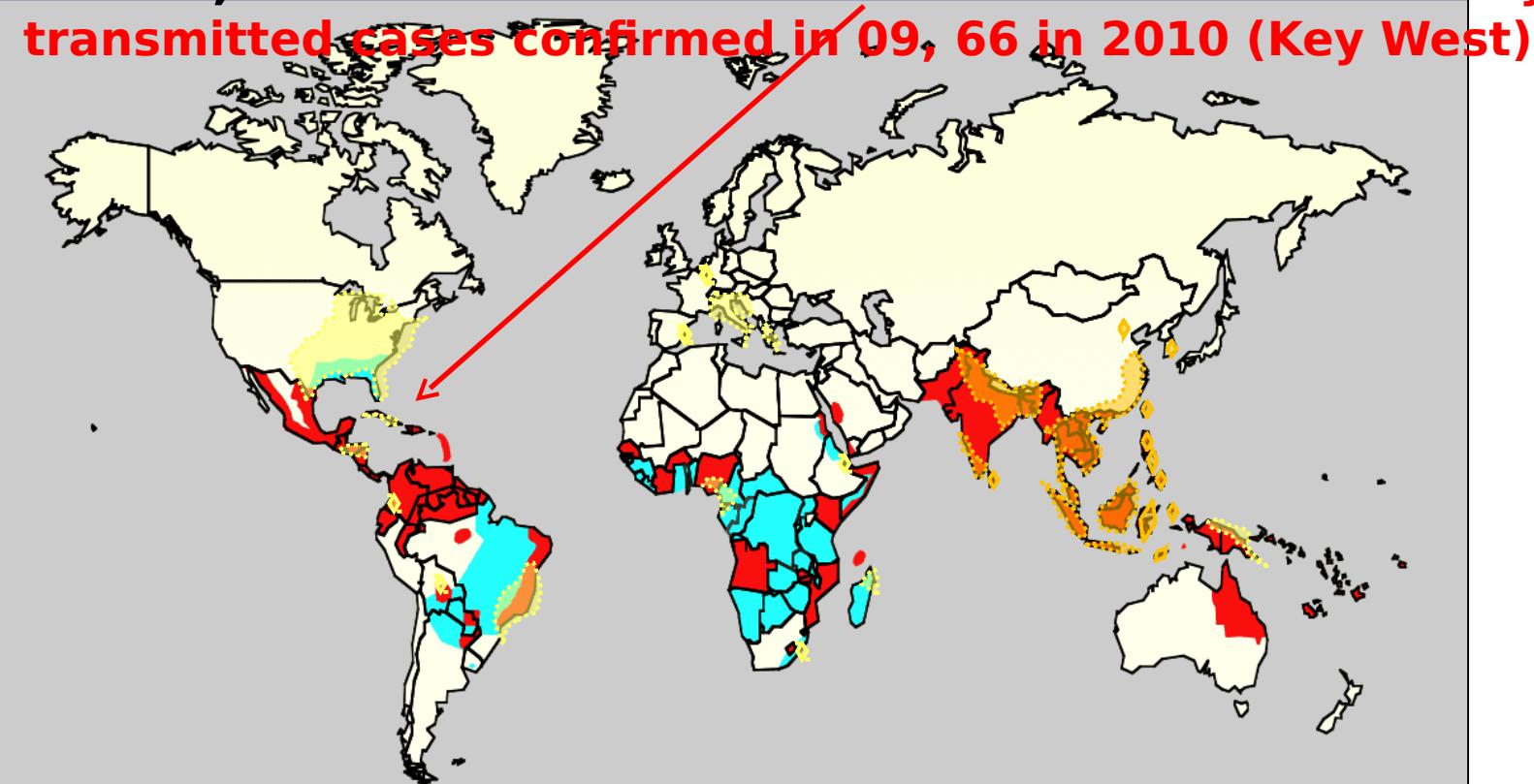
- The Americas- 876,859 cases; 406 DHF/serious
- Vietnam- 13,903 cases

-First case of secondary transmission in Miami in 50 years in Nov 10; 2 cases in 2011; first case of secondary transmission in Tampa diagnosed in Oct 2011; 4 cases in 2012; 28 cases in 2013

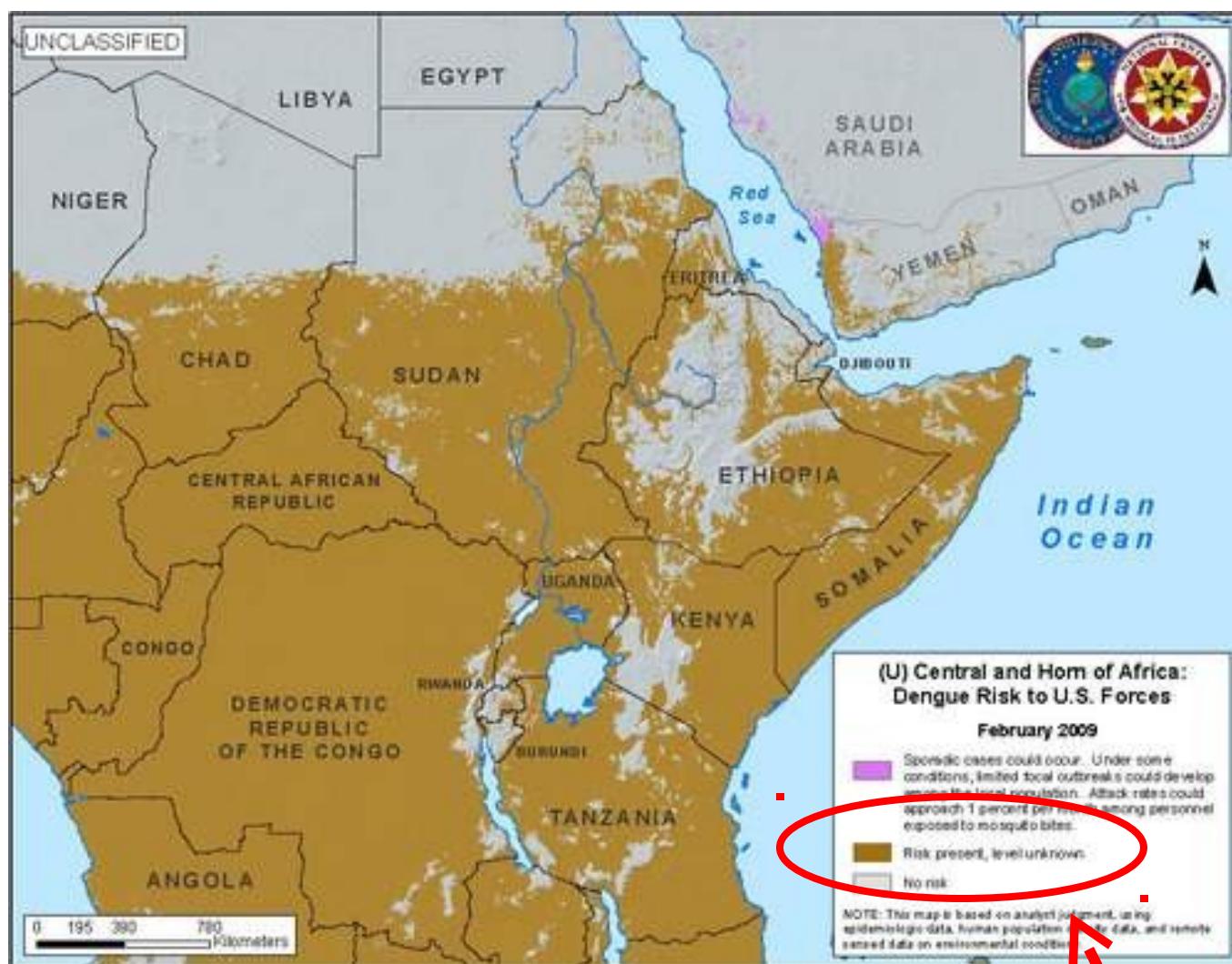
**Martin County outbreak**

## **"Dengue virus returns to Florida after more than 50 years, UF researchers say" UF News, 23 Nov 09**

**-27 locally**



# Dengue in Africa



**“Risk present, level unknown”**

# Chikungunya Fever-

**Aedes mosquitoes**

laboratory-confirmed or probable cases of chikungunya were detected among travelers returning to the United States. This compares with only three cases reported from 1995 to 2005. Since 2004, chikungunya virus has caused massive and sustained outbreaks in Asia and Africa, infecting more than 2 million people, with attack rates as high as 68% in some areas. With the movement of travelers, local transmission has taken place in areas where the virus was not previously found, including northern Italy and

PREPAREDNESS AND RESPONSE FOR CHIKUNGUNYA VIRUS / INTRODUCTION IN THE AMERICAS



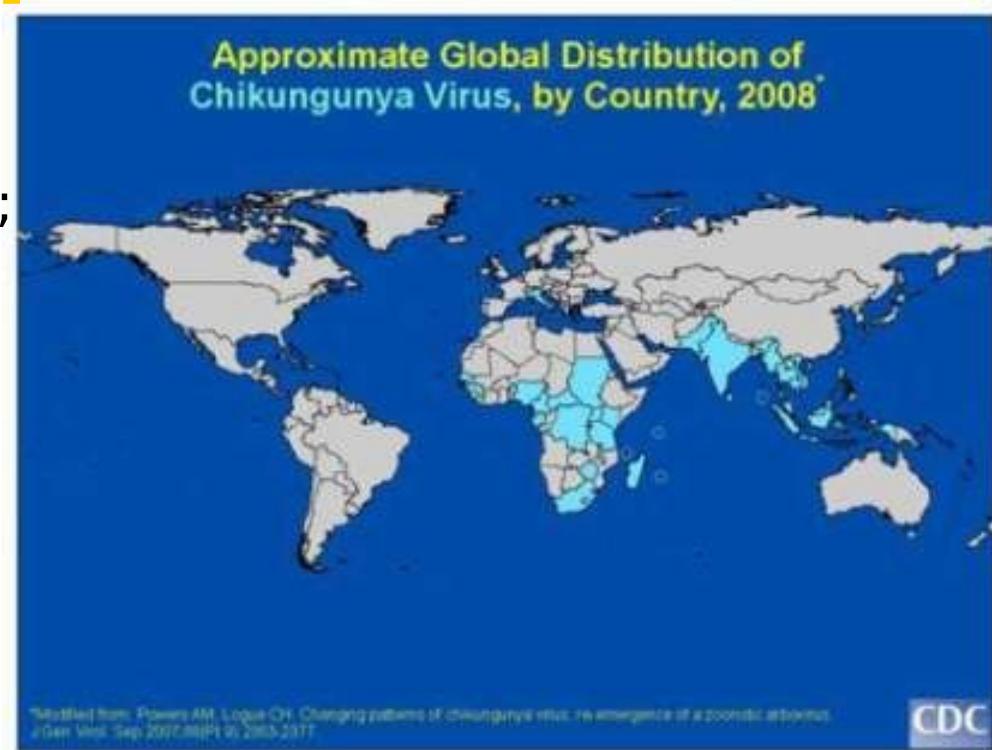
## Preparedness and Response for **Chikungunya Virus**

Introduction in the Americas



# Chikungunya Fever- Aedes mosquitoes

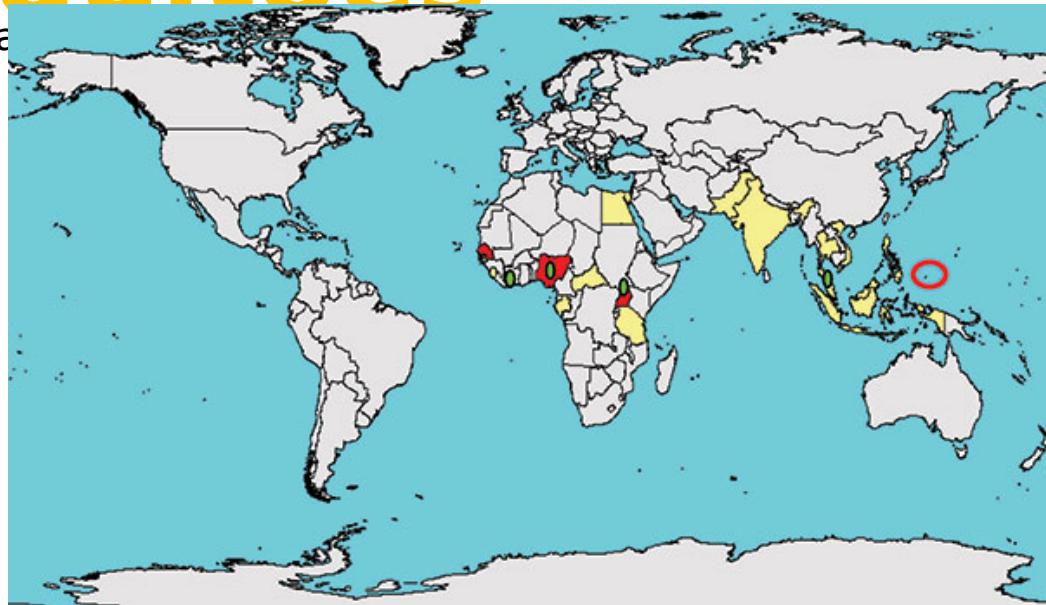
- Mosquito-borne virus
- Like dengue, traditional vector is *Ae. aegypti* but *Ae. albopictus* is competent vector; equivalent eradication challenges
- Symptomology also comparable to dengue
- Continuous outbreaks since 2005 in Europe, Asia & Africa, to include areas not previously endemic; over 200 cases in Italy in 2007
- Jun 11- Based on genomic studies from an outbreak of 480 cases in DRoC, *Ae. albopictus* is being considered as a more critical vector



- **Malaysia: Over 1,100 cases Jan - April 2009**
- **Philippines: Over 500 cases by Oct 2013**

# Zika Virus- Aedes mosquitoes

- The French Polynesia Department of Health has confirmed an outbreak of Zika fever in the islands of French Polynesia. As of January 13, 2014, **361** laboratory confirmed cases and **7,156** suspected cases have been reported
- Related to dengue, Yellow Fever, West Nile and JE
- Hosts are monkeys and humans
- ~10 day mosquito development stage
- Similar symptoms to dengue, CHIK-V



Approximate distribution  
2017-2018



Ae.  
aegypti



# Filariasis- Mosquitoes

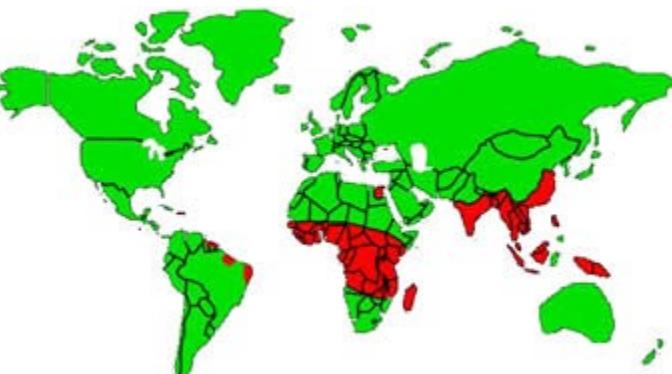
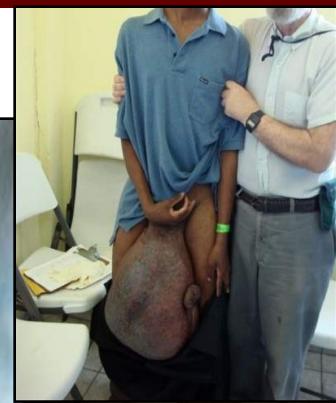
**Vector depends on the geographic area**

**-Africa: *Anopheles***

**-Americas: *Culex***

***quinquefasciatus***      **-Pacific and Asia: *Aedes* and *Mansonia***

***Biting behaviors matter!***



# Aedes Vectors



**Ae. albopictus**



**Ae. aegypti**

# Feeding Habits - *Ae. albopictus*

- *Aedes albopictus* prefers to feed and rest **outdoors**
- Feeds during daytime (diurnal)
- Feeds on any vertebrate host but prefers humans



*Aedes albopictus*



# Aedes comparison



## *Ae. aegypti*   *Ae. albopictus*

**Environment**

**Urban**

**Sylvatic\***

**Breed/feed**

**Indoors(< 200m)**

**Outdoors**

**Container type**

**Artificial**

**Natural and artificial**

**Biting peak**   **Daytime**   **Dusk**

**Host** **Human**

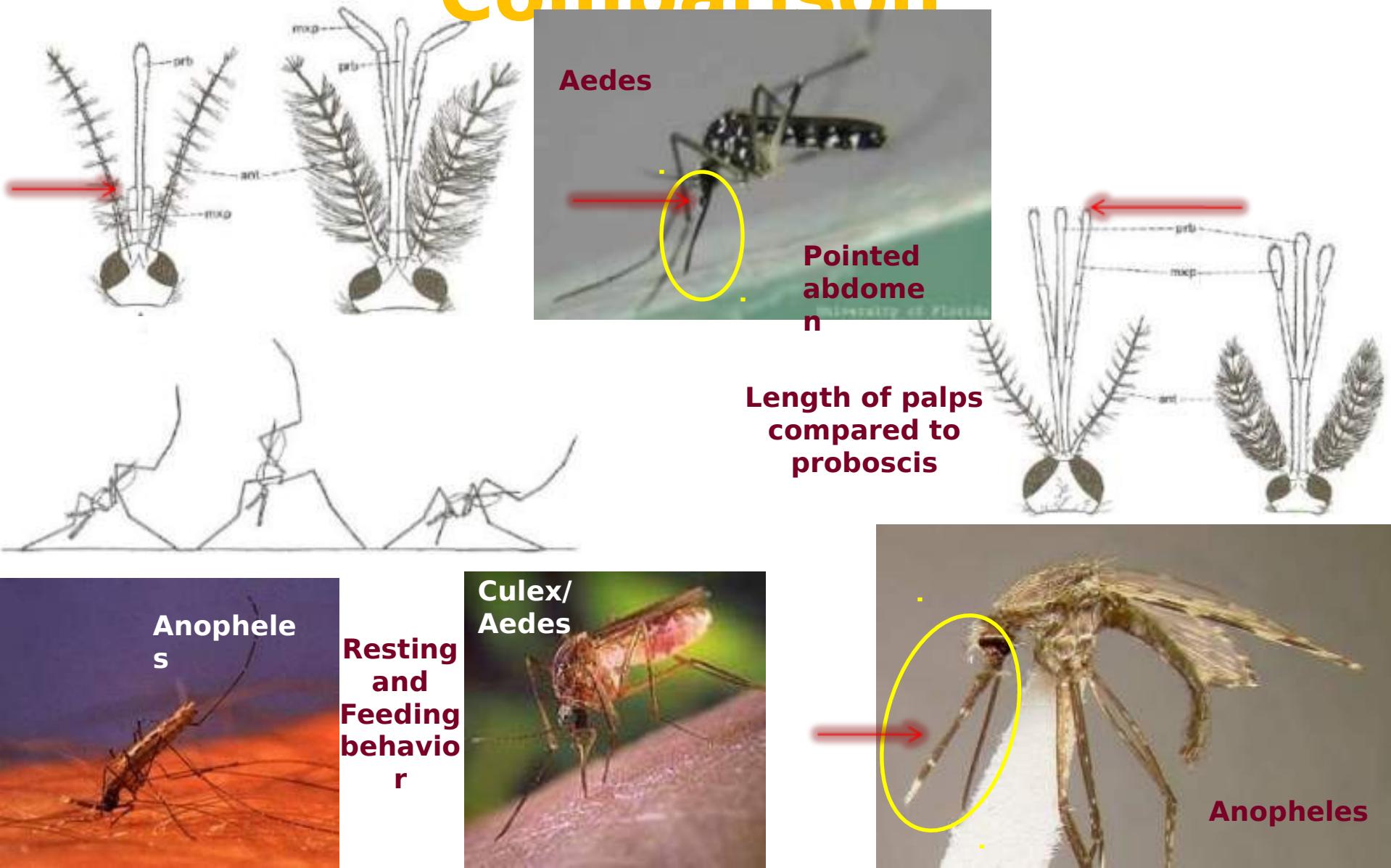
**Human/Vertebrates**

**Flight Range**

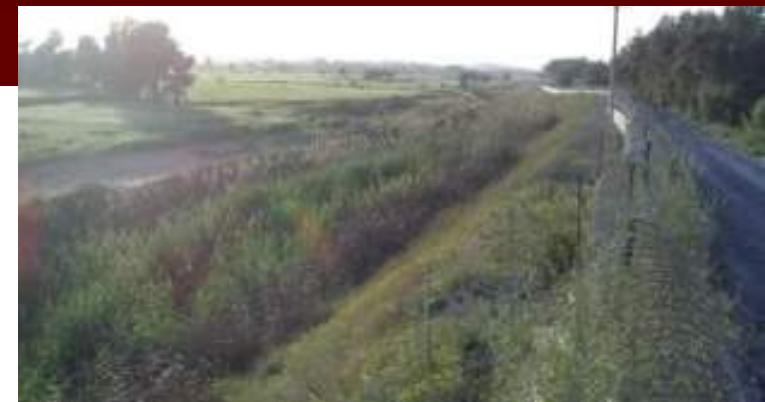
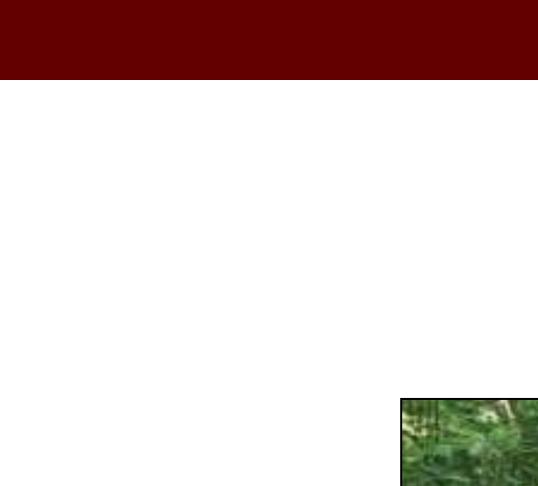
**< 200m**   **< 600m**

**\*Not necessarily**

# Mosquito Vector Comparison



# Behavior & Habitat Comparison



**Aedes, Culex:**  
stagnant, dirty,  
temp pools,  
opportunistic

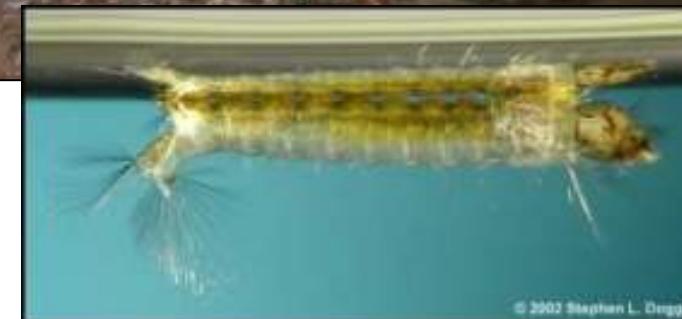


**Anophelines:** typically  
cleaner, slowly  
flowing; in some  
places temp pools ok  
as long as not  
stagnant



**Aedes, Culex:**  
body hangs  
down from the  
surface; uses  
bottom of container

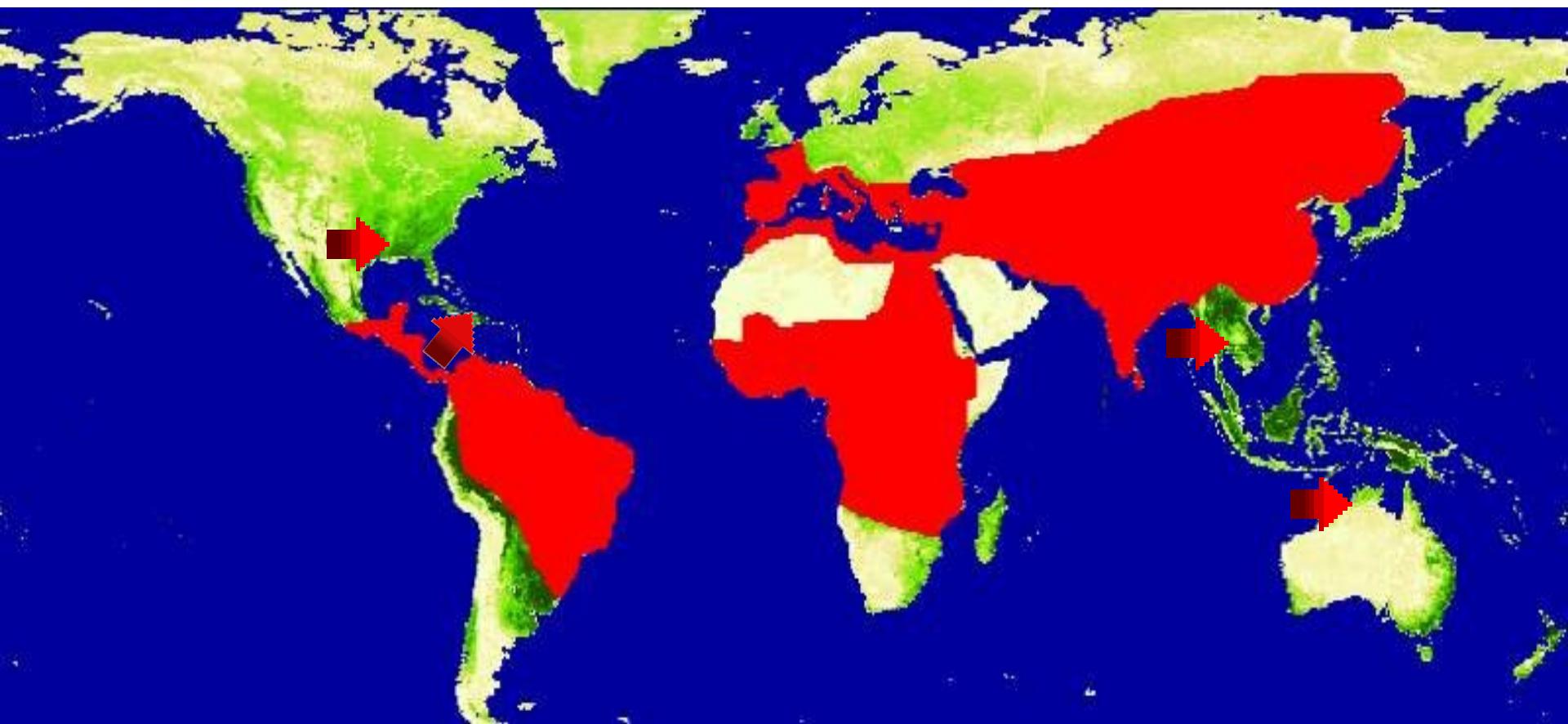
**Anopheles:**  
parallel to  
surface;  
spiracular plates  
on 8<sup>th</sup> abdominal  
segment



# Sand Flies-



# Global distribution of the leishmaniases (but not the global distribution of sand flies)



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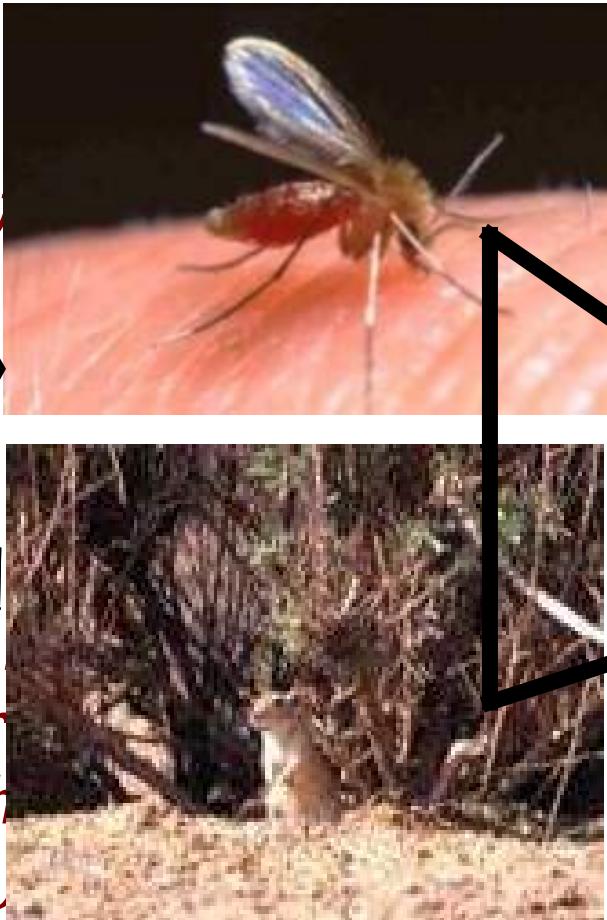


# Mucocutaneous leish from French Guyana



# The Epidemiological Enzootic Triangle

Sand fly vector



*Incidental Host*



*Man and his Activities*



# Characteristics

- Small (2-3 mm)
- Brown (but appear white when illuminated)
- Wings held in erect V-shape (even dead)
- Nocturnal
- Do not hover
- Silent
- Painful bite for som



# Leishmaniasis Sand Flies



Drain fly



Damp habitats, plumose antennae, larger, broader wings, more hair; sand fly always holds its wings up and away from its body, not flat like a drain fly



Phlebotomus (Old World) and Lutzomyia (New World) spp

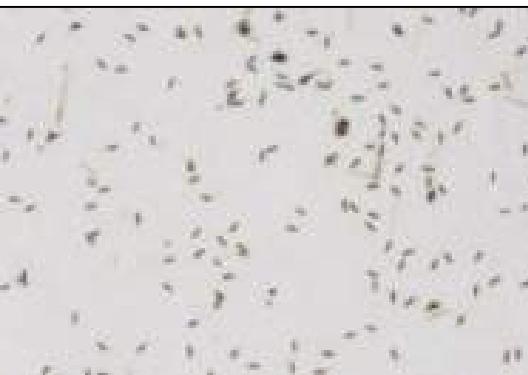


Sand fly

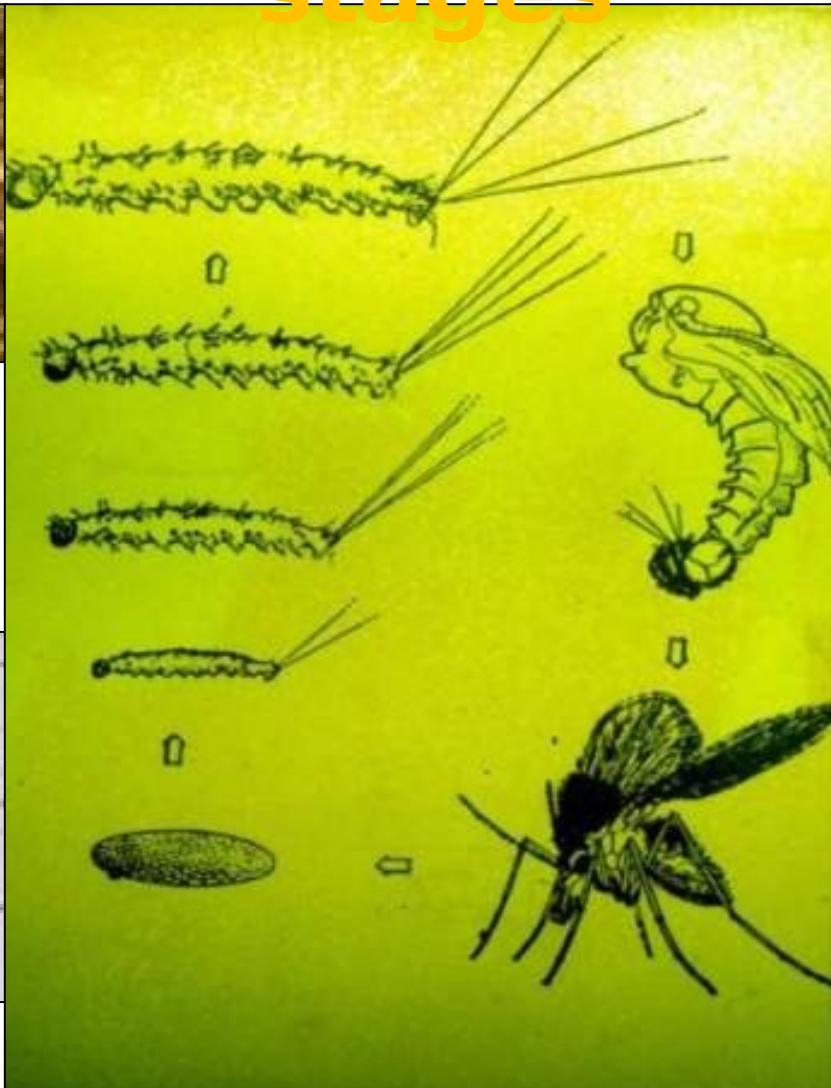
# Life cycle and developmental stages



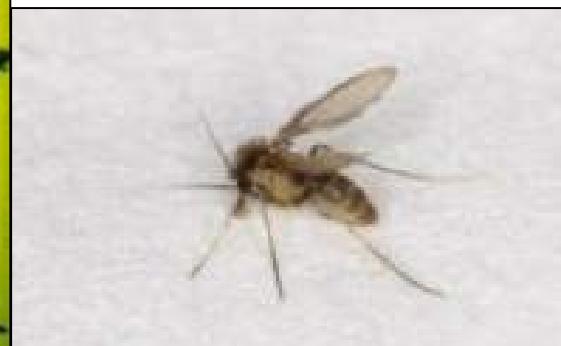
**Fourth instar larvae**



**Eggs**



**Adult male**



**Adult female**

# Sand flies - vital requirements

- Larvae breed in soil (not aquatic)
- Only females take blood, from a variety of vertebrate species
- Rest during the day in dark, humid microhabitats
- Both sexes require sugar as an energy source

# **Sand flies resting on wall of a chicken house**



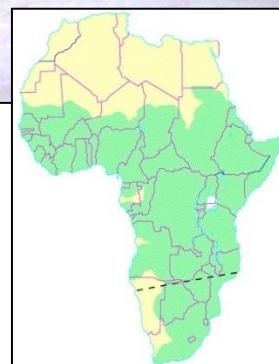
# Variable Habitats: rain forest, desert,



# African Tick Bite Fever-Ticks

African tick-bite fever (ATBF)

- an emerging infectious disease endemic in sub-Saharan Africa
- the most commonly encountered rickettsiosis in travel medicine.
- *Rickettsia africae*
- *Amblyomma, Dermacentor, Rhipicephalus*

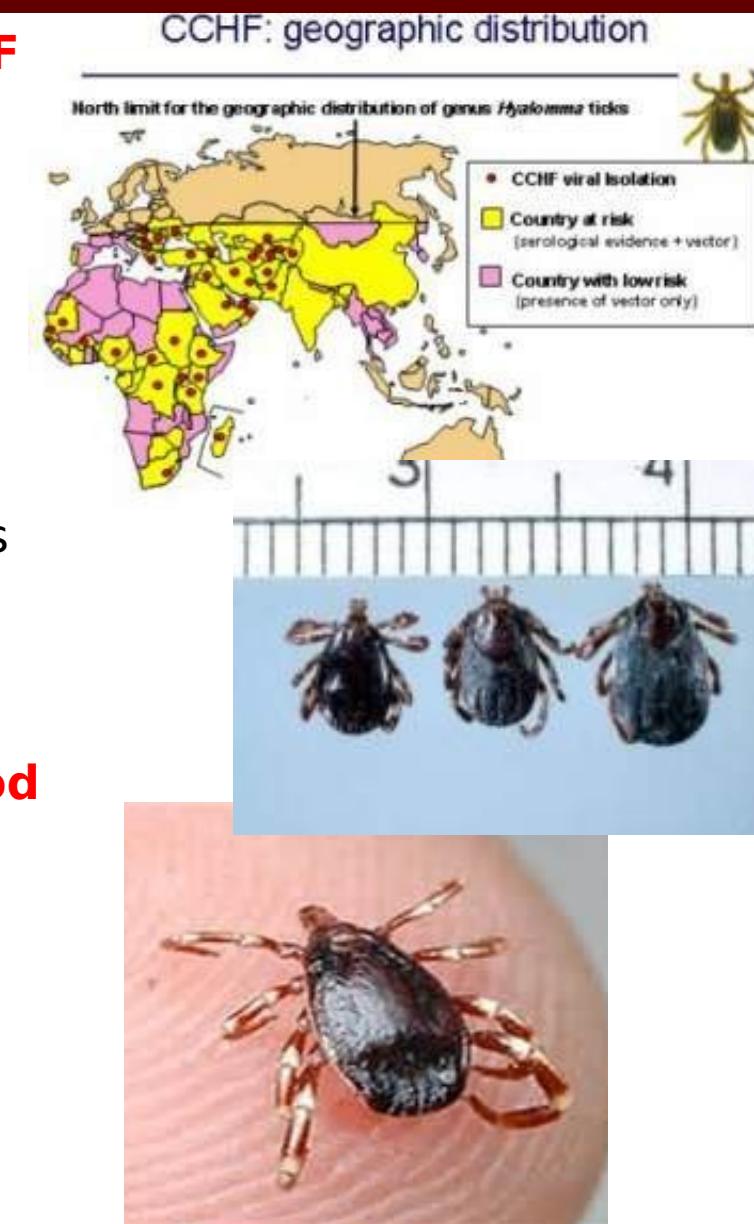


1. Ndip et al., 2011. Risk Factors for African Tick-Bite Fever in Rural Central Africa. *Am. J. Trop. Med. Hyg.*

2. Raoult et al., 2001. *Rickettsia africae*, a tick-borne pathogen in travelers to sub-Saharan Africa. *N Engl J Med*

# Crimean Congo Hemorrhagic Fever-Ticks

- **Sep 09: First US Soldier death from CCHF since WWII; acquired in AFG (Arghandab Valley)**
- Tick-borne virus (*Hyalomma*); 30% mortality rate
- **Can also be transmitted by exposure to fresh infected blood (human or animal)**
- Endemic in many countries in Africa, Europe, Asia and the Mediterranean; since 2001 cases or outbreaks have been recorded in Kosovo, Albania, Iran, Pakistan, and South Africa
- **Most widely distributed HF in the world**
- **Austere conditions increase the likelihood of transmission; fewer “tick checks”, formal or informal**
- Intensive monitoring of blood volume and component required

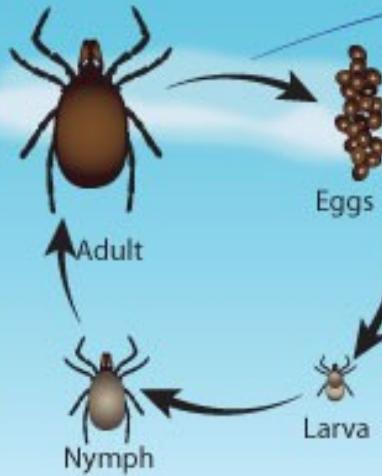


# Crimean-Congo Hemorrhagic Fever (CCHF) Virus Ecology

## Enzootic Cycle

Ixodid (hard) ticks are both a reservoir and vector for the CCHF virus.

The virus is maintained in nature transovarially and transstadially.



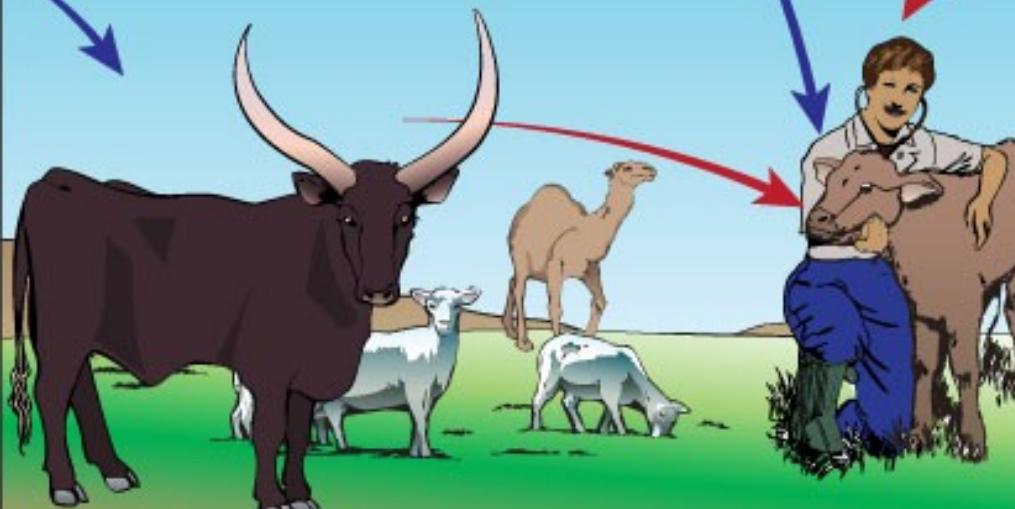
## Epizootic-Epidemic Cycle

CCHF cases occur more during the warmer parts of the year, mostly the spring and summer. There are no cases during the winter.

Humans become infected through tick bites and direct contact with infected animal blood or tissue.

Transmission can occur while slaughtering infected animals, during veterinary procedures, and in hospital settings where proper protective equipment and appropriate disinfection procedures are lacking.

The ticks feed on numerous wild and domestic animals, such as cattle, goats, sheep and hares. These animals serve as both food sources for ticks and amplifying hosts for the virus.





# Tick Removal

U. S. Army Center for Health Promotion and Preventive Medicine

## REMOVE TICKS PROMPTLY

\* If a tick is found attached to the body (Figure 1), seek assistance from medical authorities for proper removal, or follow these guidelines:

- (1) **Grasp the tick's mouthparts** against the skin, using pointed tweezers (Figure 2).
- (2) **Pull back slowly and steadily** with firm force.
  - (a) Pull in the reverse of the direction in which the mouthparts are inserted, as you would for a splinter (Figure 2).
  - (b) **BE PATIENT** – The long, central mouthpart (called the hypostome) is inserted in the skin. It is covered with sharp barbs, sometimes making removal difficult and time-consuming (Figure 3, inset).
  - (c) Most ticks secrete a cement-like substance during feeding. This material helps secure their mouthparts firmly in the flesh, further adding to the difficulty of removal.

(d) It is important to continue to pull steadily until the tick can be eased out of the skin (Figure 3).

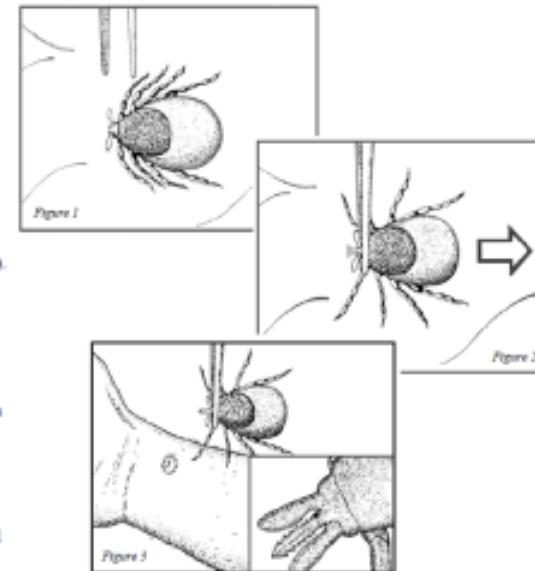
(e) **DO NOT** pull back sharply, as this may tear the mouthparts from the body of the tick, leaving them embedded in the skin. If this happens, do not panic. Embedded mouthparts are comparable to having a splinter in your skin. Mouthparts alone cannot transmit disease because the infective body of the tick is no longer attached. However, to prevent the chance of secondary infection, it is best to remove them. Seek medical assistance if necessary.

(f) **DO NOT** squeeze or crush the body of the tick because this may force infective body fluids through the mouthparts and into the wound site.

(g) **DO NOT** apply substances such as petroleum jelly, finger nail polish, finger nail polish remover, repellents, pesticides, or a lighted match to the tick while it is attached. These materials are either ineffective, or worse, might agitate the tick and cause it to force more infective fluid into the wound site.

\* Following removal of the tick, wash the wound site (and your hands) with soap and water and apply an antiseptic.

\* **Save the tick** for future identification should you later develop disease symptoms. Preserve it by placing it in a clean, dry jar, vial, small Ziploc plastic bag, or other sealed container and keeping it in the freezer. Identification of the tick will help the physician's diagnosis and treatment, since many tick-borne diseases are transmitted only by certain species.



\* You may discard the tick after one month; all known tick-borne diseases will generally display symptoms within this time period.

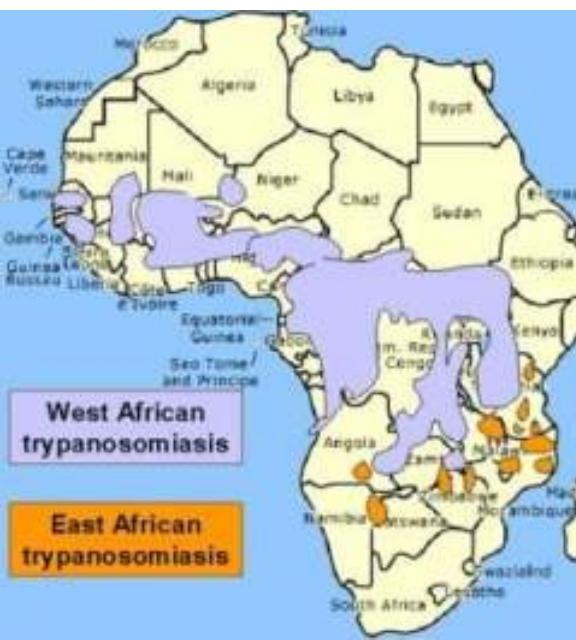
\* A tick needs a blood meal from a host in order to molt (progress to the next stage of its life cycle), and to reproduce (lay eggs). This feeding process continues for several days to a week until the tick is fully engorged with blood. It then releases its hold on the host, drops off, and subsequently molts or lays eggs.

\* If the tick is infected with pathogenic organisms (for example, *Borrelia burgdorferi*, the agent of Lyme disease), it can transmit the infection to the host during the feeding process. As the tick feeds, the pathogens multiply, migrate to the tick's salivary glands, and are carried into the wound site along with the saliva.

\* Successful transmission of pathogens requires the tick to be attached for at least several hours. Therefore, the sooner infective ticks are removed, the less likely they will be able to transmit infection. It is impossible to tell if a tick is infected just by looking at it. Only analysis in a laboratory can determine infection status.



# HAT and Nagana



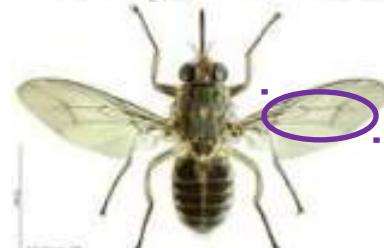
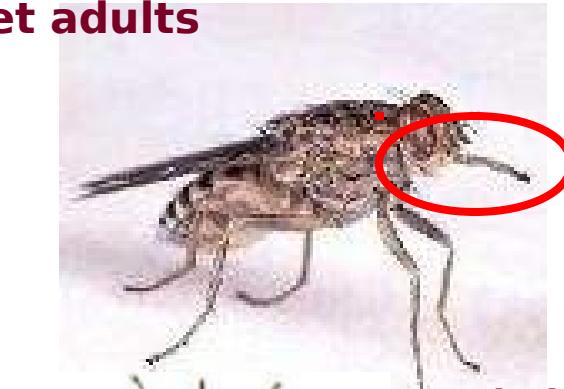
Over 50% of the landcover in Africa is considered "highly suitable" to the tsetse fly; both sexes take blood



# African Trypanosomiasis



Larvae are soil dwelling so control measures target adults



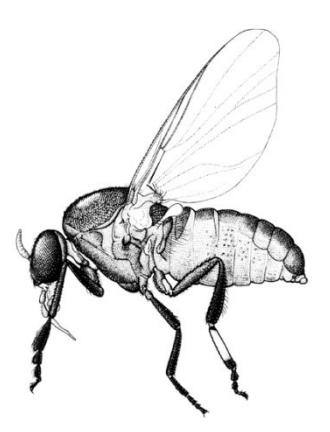
Distinct features: long proboscis, calyptate antennae, ptilinal suture, the wings overlap completely when held over the abdomen, the discal medial (i.e. the middle) cell of the wing has a characteristic hatchet shape; and it has a yellowish brown Marginal Cell.

Glossinidae

# Onchocerciasis- Black Flies



- Simulium* complex breed in fast-flowing streams and rivers hence the commonly known name of “river blindness”
- Large flight range
- Larval stage is targeted by control programs
- Painful daytime bite; “pool feeders”, ideal for transmission of microfilarial into skin



■ Countries with onchocerciasis (river blindness)

# Prevention

# WHAT CAN YOU DO TO MINIMIZE RISK?

- Find out what the priority risks are in your area before you deploy.
- Understand the vectors so you can avoid them.
- Modify behaviors to minimize contact
  - Use **repellents**
  - Sleep under insecticide treated netting
  - Wear permethrin treated uniforms
- Take malaria chemo (if warranted)
- Call for help:
  - AFPMB (CLO) : afpmb-webmaster@osd.mil: subject CLO question
  - PHC, Ento Division

# Standard Military DEET Skin Repellent

Commercial



Military



**33% Controlled-Release DEET Lotion: NSN 6840-01-284-3982**

Highest rated skin repellent available (Consumer Reports, May 2003; reconfirmed 2013-14)

# CDC recommended repellents

- Of the active ingredients registered with the EPA, products containing these active ingredients typically provide longer-lasting protection than others:

## **DEET, Picaridin and IR3535**

- The non-DEET compounds work as well as or nearly as well as DEET when they are used at higher concentrations (~10-20%).

<http://www.cdc.gov/ncidod/dvbid/westnile/repellentupdate.htm>

[http://www.epa.gov/pesticides/health/mosquitoes/ai\\_insectrp.htm](http://www.epa.gov/pesticides/health/mosquitoes/ai_insectrp.htm)

<http://www.entomology.wisc.edu/mosquitosite/topicalrepel.html>

# Picaridin



- Picaridin is a colorless, nearly odorless liquid active ingredient that is recommended by the CDC as an alternative to DEET.
- Lab and field studies of products containing picaridin (**10-20%**) indicate good protection.
  - 7.5% products are not as effective.
- **Natraptel, 20%, 3.5-oz. Pump Spray**
- Cutter Advanced, 7%, 6-oz. Pump Spray
- Off Skintastic, 5%, 6-oz. Pump Spray



# IR3535

- IR3535 is recommended by the CDC as an alternative to DEET.
- IR3535 is a synthetic insect repellent structurally similar to a natural amino acid, beta-alanine and is classified as a biopesticide by the EPA.
- This compound has been used as a mosquito repellent in Europe and Asia for 10-20 years
- Approved by the U.S. EPA in 1999.
- IR3535 is currently available in the Avon Skin-so-soft Bug Guard **7.5%**



# Treated Uniforms



- A new training briefing on permethrin-treated Flame-Resistant Army Combat Uniforms (FR ACUs) is available -CAC REQUIRED
- <https://www.us.army.mil/suite/doc/28282876>
- <https://peosoldier.army.mil/newpeo/ContactUs/faqs/fracu.asp>

# Bed Nets



**Enhanced BedNet System 3740-01-546-4354**

**Improved Bed Net System 3740-01-543-5652**

**Bed net, Pop-up, self-supporting  
Coyote Brown 3740-01-518-7310**

OD Green (Camo) 3740-01-516-4415

**NSN 3740-01-518-7310- CL 0X item,  
must be ordered  
through CL IX SARSS**

The pop-up bed net is factory-treated with permethrin and has much finer mesh than the standard military bed net.

# Myth Busters



- No evidence that eating garlic or taking vitamin B tablets reduces mosquito bites
- Dark clothing is usually more attractive than light colored clothing
- Drinking alcohol may increase your attractiveness to mosquitoes

# Myth Busters

- Some mosquito control devices use repellents to protect a small outdoor area like a patio
- No products approved by the EPA for indoors
- Effective devices which use **allethrin** or other **pyrethroids** to repel mosquitoes include:
  - Mosquito coils
  - ThermaCell <sup>(TM)</sup> Mosquito Repellent System

# Myth Busters



**Mosquito magnet can be very effective for area coverage**

# Myth Busters

- Citronella candles are weak
- Geraniol candles can provide 1 meter of protection



# Myth Busters

- Sonic and electronic devices do not work



# Final Thoughts

- Vaccine preventable diseases
  - Yellow Fever

## Socioeconomic Instability

- Displaced persons/refugees
- Disaster response

} 2<sup>nd</sup> & 3<sup>rd</sup> Order Effect

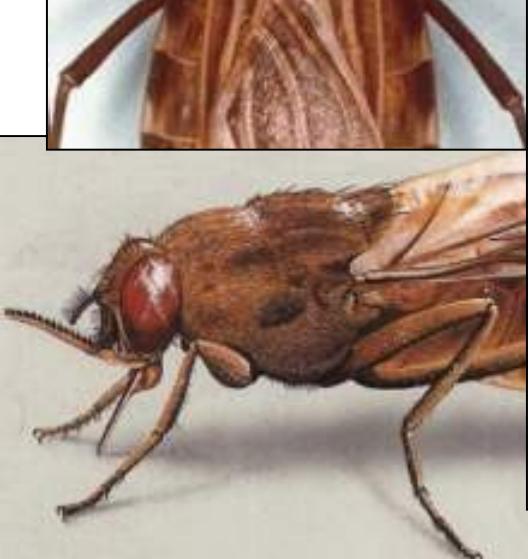
# References/Resources (1 of 2)

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- Knowlton, K., Solomon, G. and M. Rotkin-Ellman. Mosquito-Borne Dengue Fever Threat Spreading in the Americas. NRDC Issue Paper. July 2009.
- WRAIR 1367 Project 002. USASOC Dengue Seroprevalence Protocol. 10 Sep 09.
- <http://www.promedmail.org/>
- Evaluation of SD BIOLINE Chagas Ab Rapid kit. *Korean J Lab Med.* 2009 Feb;29(1):48-52.
- [www.gideononline.com](http://www.gideononline.com)
- [http://www.plosntds.org/article/slideshow.action?  
uri=info:doi/10.1371/journal.pntd.0000196&imageURI=info:doi/10.1371/journal.pntd.0000196.g001](http://www.plosntds.org/article/slideshow.action?uri=info:doi/10.1371/journal.pntd.0000196&imageURI=info:doi/10.1371/journal.pntd.0000196.g001) for dengue algorithm.

# More Resources (2 of 2)

- ASTMH Intensive Short Course, Annual Pre-Meeting Course and Conference 2009, 2010, 2011. [www.astmh.org](http://www.astmh.org)
- <http://www.cdc.gov/eid/content/14/5/pdfs/814.pdf> for *P. knowlesi* article.
- Field Guide to Medically Important Invertebrates Affecting Military Operations. Jun 2006.
- [http://www.afpmb.org/pubs/Field\\_Guide/field\\_guide.htm](http://www.afpmb.org/pubs/Field_Guide/field_guide.htm)
- Medical Entomology: An Ecological Perspective. G.A.H. McClelland. 12<sup>th</sup> Edition. 1992.
- An Introduction to the Study of Insects. Borrer, Triplehorn, Johnson. 12<sup>th</sup> Edition.
- Tsetse fly habitat and land cover: an analysis at continental level. <ftp://ftp.fao.org/docrep/fao/010/i0215e/i0215e01.pdf>
- The Social Ecology of Infectious Diseases. Mayer and Pizer. 1<sup>st</sup> Edition. 2008.

# Questions?



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